Using Artificial Intelligence to Predict Coal Seam Compressibility, Compaction and Subsidence

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Project Overview

The goal of this project is to develop a workflow for improving the description of the **internal structure of coal, and related coal properties**, at the metre scale with an accuracy that could only be achieved using micrometre-scale data. This will be achieved by employing **artificial intelligence algorithms** to process input imaging data and enhance their quality. This project will result in **more accurate analysis of coal seam behaviour during gas production** and improve **predictions of potential surface subsidence resulting from reservoir depletion**. This will help inform the optimum design and location of additional wells to **maximise gas production and minimise potential subsidence** to ensure balanced coexistence of gas exploration and agricultural practices in Queensland. Creating a predictive modelling workflow will ensure that the increase of coal seam gas exploration volumes, which is planned for Queensland to supply natural gas to local and international customers and sustain economic growth and post-pandemic recovery, will not impact local agricultural activity.

Project Objectives

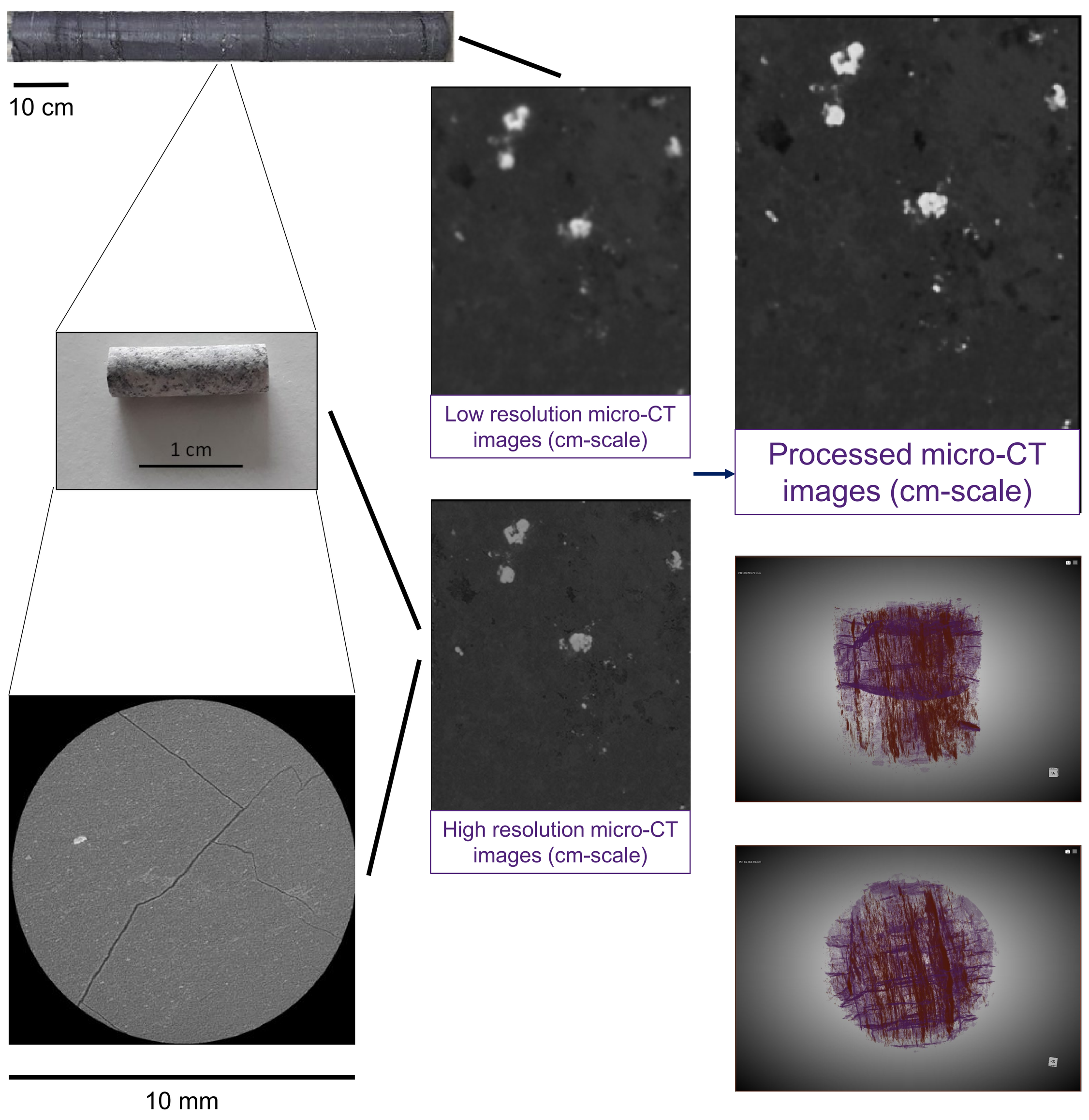
1. Super-resolution (SR) processing of centimetre- to micrometre-scale CT images using convolutional neural networks (CNN) to extract cleat networks, analysis of permeability and coal cleat distribution;
2. Combination of CT data and wellbore logging data to link compressibility, permeability, and coal cleat distribution.
3. Correlation between the analysed wells and all wells in the area of investigation, predicting the behaviour of coal seams during CSG production.

Project Concept

Input Wells	Validation Wells	Application Wells
THREE WELLS CHOSEN REFERENCE WELLS from INDUSTRY PARTNERS WELLS USED to CREATE MODELS and WORKFLOWS which CONTAIN FULL BOREHOLE and CORE DATASETS	SEVERAL WELLS OTHER WELLS OBTAINED from the INDUSTRY PARTNERS WELLS USED TO TEST and VALIDATE DEVELOPED MODELS and WORKFLOWS	MULTIPLE WELLS ALL OTHER CSG WELLS from ANY AREA of INTEREST WELLS USED TO APPLY VALIDATED MODELS and WORKFLOWS

Project Execution Workflow

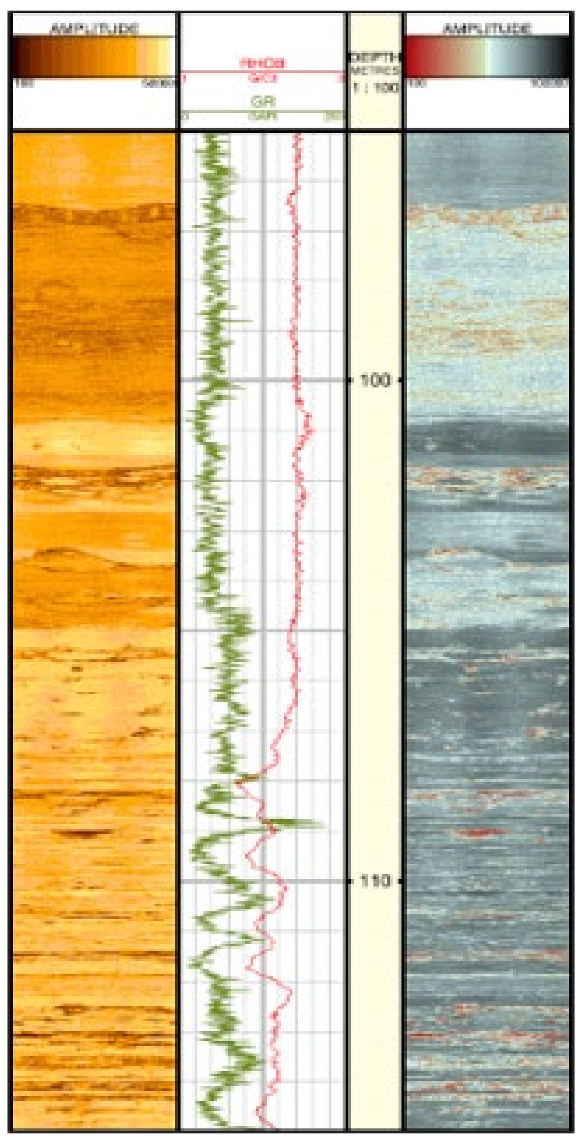
First Stage



micrometre-, millimetre-, and centimetre-scale

Figure 1: Super-resolution processing of low-resolution to high-resolution micro-CT images using convolutional neural networks, analysis of permeability and coal cleat distribution

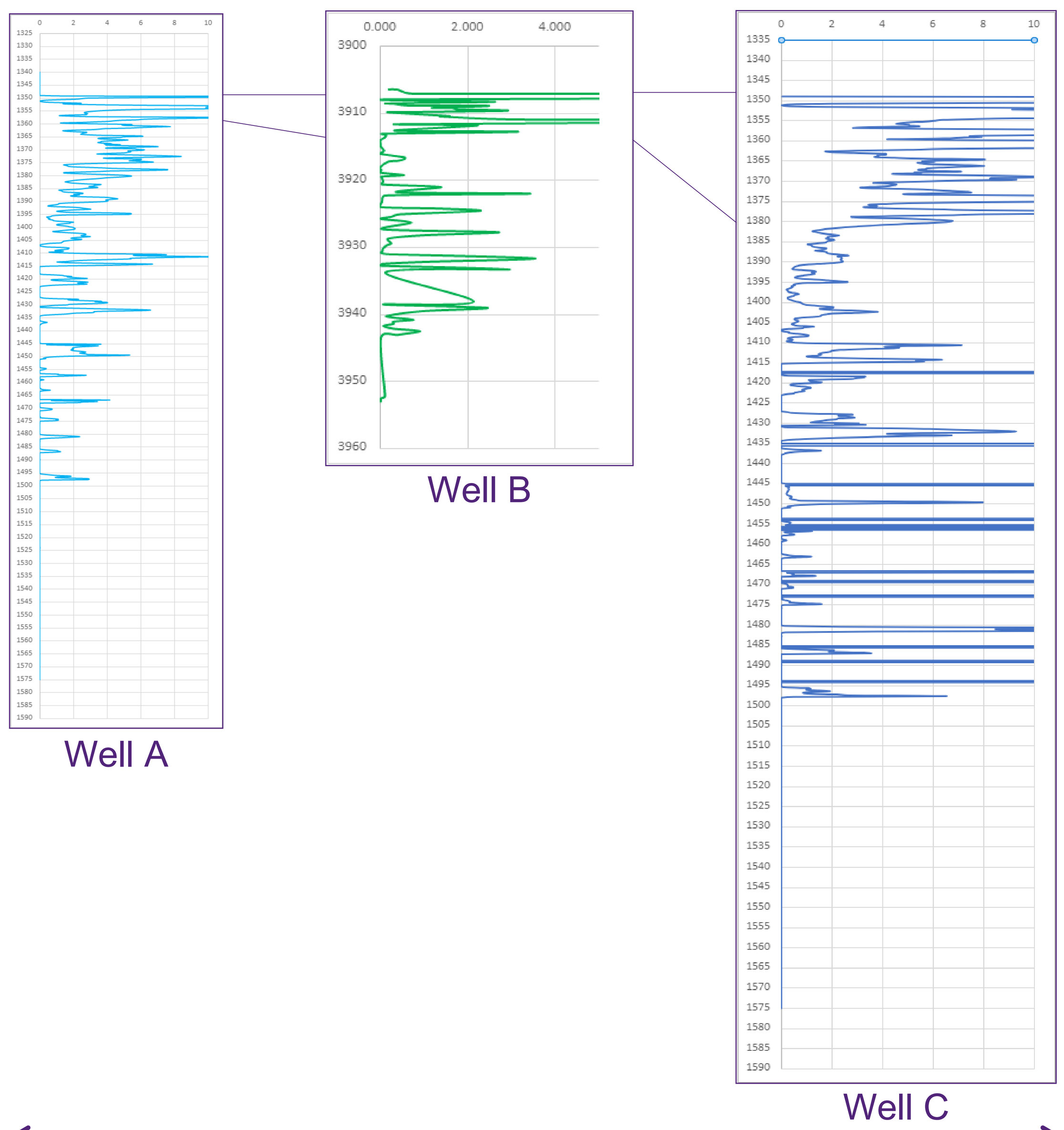
Second Stage



metre-scale

Figure 2: Combination of CT data and wellbore logging and imaging data to link compressibility, permeability and coal cleat distribution

Third Stage

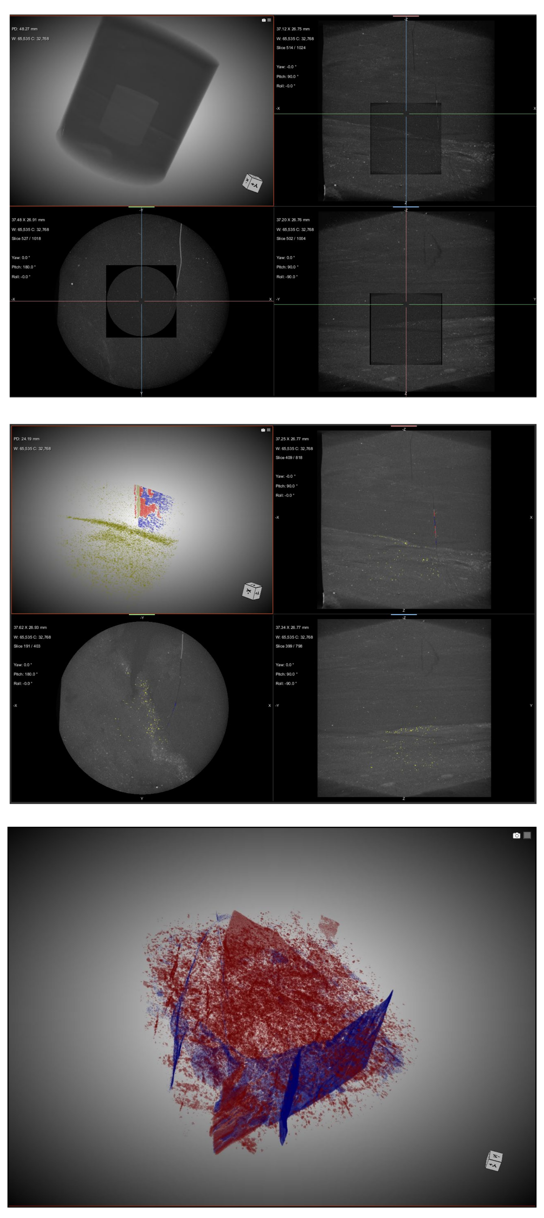


metre- and kilometre-scale

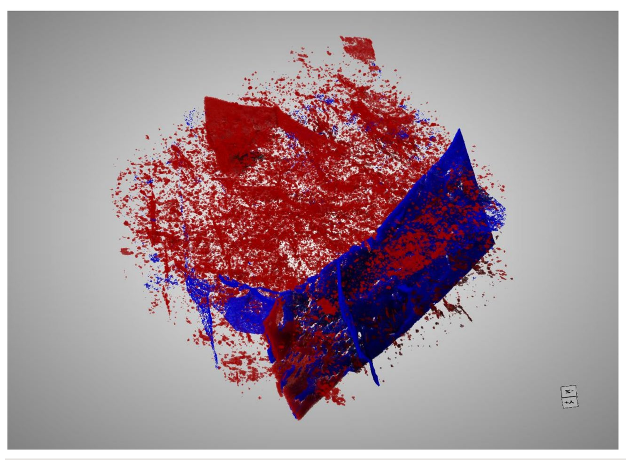
Figure 3: Correlation between the analysed wells and all wells in the area of investigation; predicting the behaviour of the coal seams during CSG production

Current Results

Combination of Images and Processing



Scanning Under Pressure (Seven Image Sets at Different Stress)



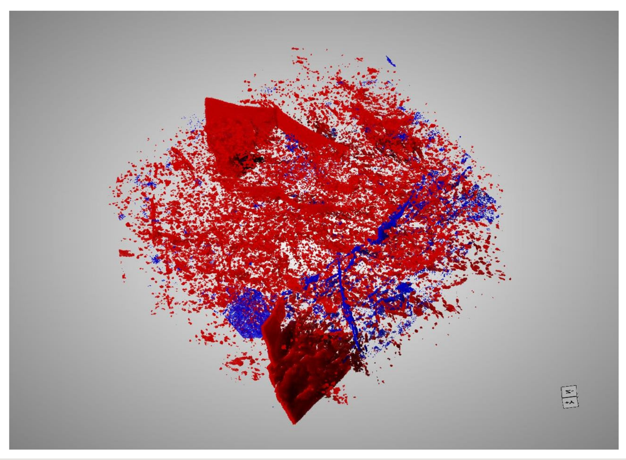
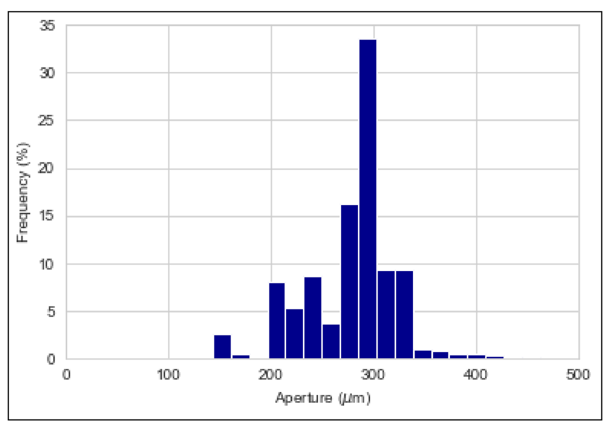
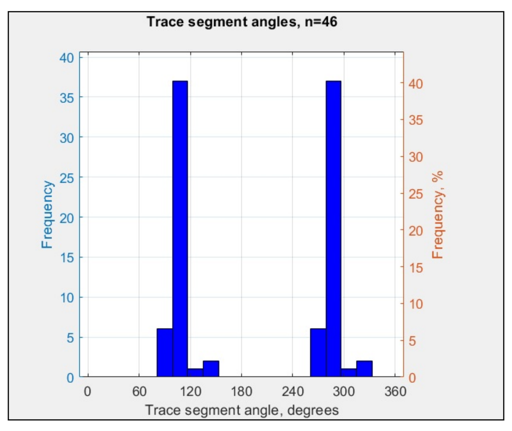


Image set	Stress
#1	0.5 MPa (lateral)
#2	5 MPa (lateral)
#3	10 MPa (lateral)
#4	0 MPa
#5	0 MPa after 70 days
#6	5 MPa (lateral and axial)
#7	10 MPa (lateral and axial)

Statistics of Coal Cleats and Calculated Aperture, Porosity, and Compressibility





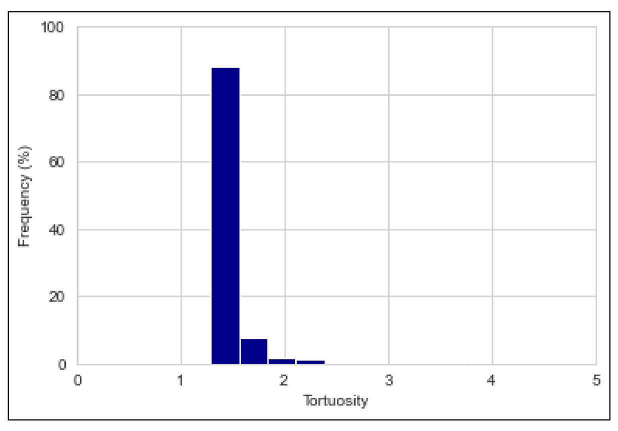
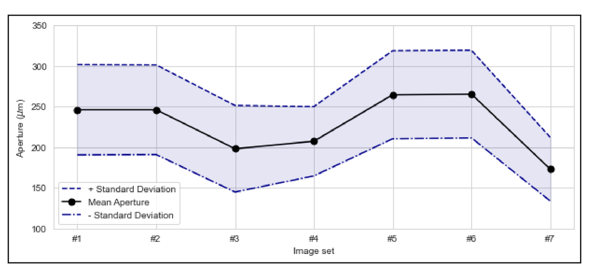


Image set	Mean aperture (μm)	Porosity (%)
#1	246.20	0.75
#2	246.30	0.75
#3	198.17	0.25
#4	207.40	0.41
#5	264.67	0.64
#6	265.48	0.63
#7	172.99	0.17

Stress	$\Delta\phi$ (%)	ϵ_V	ΔP (MPa)	k (MPa)
Lateral	0.500	0.00500	9.5	1901.14
Lateral and axial	0.470	0.00470	10	2127.66



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