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

Dr Alexandra Roslin1,2, Prof Maxim Lebedev3, Dr Christopher Leonardi1,2
1 School of Mechanical and Mining Engineering, The University of Queensland, St Lucia, QLD, Australia
2 Centre for Natural Gas, The University of Queensland, St Lucia, QLD, Australia
3 West Australian School of Mines, Curtin University, Perth, WA, Australia

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

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

Project Execution Workflow

First Stage
Combination of Images and Processing
Scanning Under Pressure (Seven Image Sets at Different Stress)
Statistics of Coal Cleats and Calculated Aperture, Porosity, and Compressibility

Second Stage
Combination of CT data and wellbore logging and imaging data to link compressibility, permeability and coal cleat distribution

Third Stage
Combination of images and processing
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.
Figure 2: Combination of CT data and wellbore logging and imaging data to link compressibility, permeability and coal cleat distribution.
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.

Acknowledgements
This work has been supported by the Advance Queensland Industry Research Fellowship Scheme (AQRFP137/2018) and the proponents of the UQ Centre for Natural Gas (Australia Pacific LNG, Santos, Arrow Energy).