An investigation of numerical facies models of coal seam gas reservoirs; Walloon Subgroup, Surat Basin

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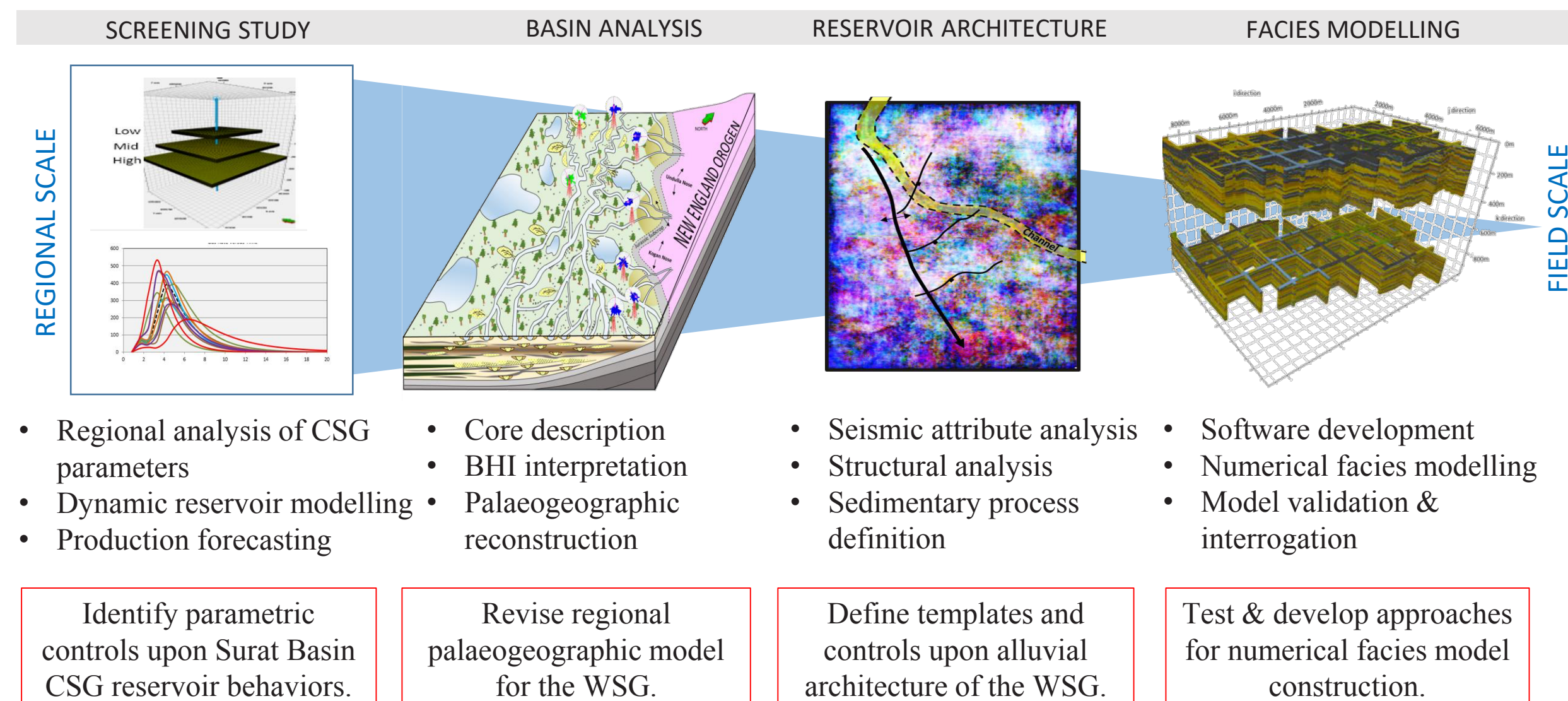
INTRODUCTION

The Walloon Subgroup (WSG) represents a prolific coal seam gas (CSG) resource which underpins three large CSG to liquefied natural gas (LNG) projects operating along the Australian east coast. These mega-projects require long term forecasts of gas production, predictions which are often derived via the dynamic simulation of numerical reservoir models. Reservoir models consist of hierarchical collections of inter-related rock and fluid parameters.

The facies model, representing paleogeography, serves as the foundation of this linkage as it defines the three-dimensional (3D) geometry and distribution of coal seams. This thesis is comprised of complementary studies aimed at investigating and enhancing the predictive capability of numerical facies models in the Walloon Subgroup.

Construction of predictive facies models requires a comprehensive understanding of regional depositional trends, local facies architectures and depositional processes as well as computer routines able to translate this information into numerical 3D grids.
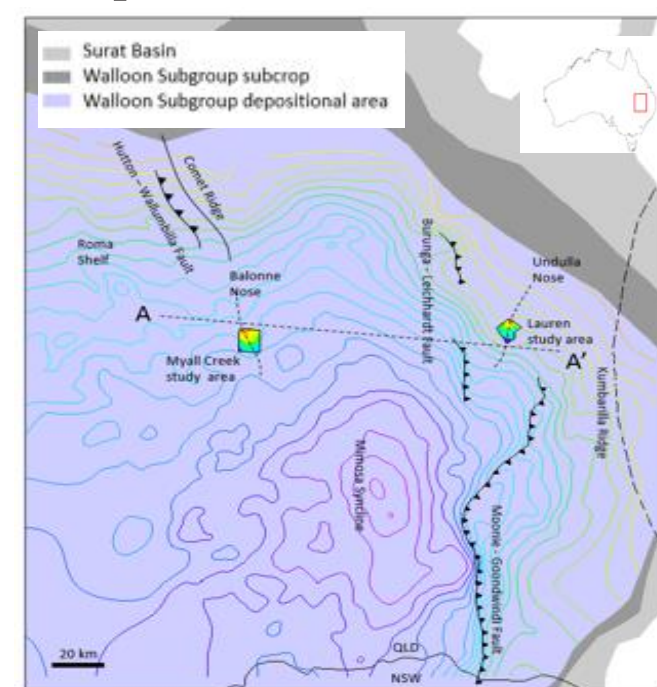
COMPONENTS REQUIRED FOR INCREASINGLY PREDICTIVE CSG FACIES MODELS

| SCREENING STUDY | BASIN ANALYSIS | RESERVOIR ARCHITECTURE | FACIES MODELLING |

REGIONAL SCALE → FIELD SCALE

- Regional analysis of CSG parameters
- Dynamic reservoir modelling
- Production forecasting

- Core description
- BHI interpretation
- Palaeogeographic reconstruction

- Seismic attribute analysis
- Structural analysis
- Sedimentary process definition

- Software development
- Numerical facies modelling
- Model validation & interrogation

Identify parametric controls upon Surat Basin CSG reservoir behaviors.

Revise regional palaeogeographic model for the WSG.

Define templates and controls upon alluvial architecture of the WSG.

Test & develop approaches for numerical facies model construction.

Screening study: A preliminary simulation study was undertaken to understand the controls upon CSG production in the Surat Basin.

Basin analysis: A regional study was undertaken to develop a consistent regional stratigraphic framework and confirm the WSG depositional model.

Reservoir architecture: A 3D seismic survey was used to develop templates describing the 3D architecture of WSG reservoir units and interrogated to elucidate the processes controlling WSG deposition.

Facies modelling: A PETREL plugin was developed in which automata representing the process of differential compaction driven compensational stacking are used explicitly to condition facies model outcomes.

Present gaps in our understanding highlight the requirement for further studies aimed at 1) refinement of the WSG's regional stratigraphic and palaeogeographic models, 2) delineation of the WSG's reservoir scale internal alluvial architecture, 3) identification of the processes or mechanisms controlling reservoir-scale facies relationships within the WSG and 4) development of workflows better able to represent alluvial facies in numerical reservoir models. The focus of this dissertation is to explore these conceptual gaps leading to improved numerical facies models of the WSG.

FACIES MODELLING ADVANCES
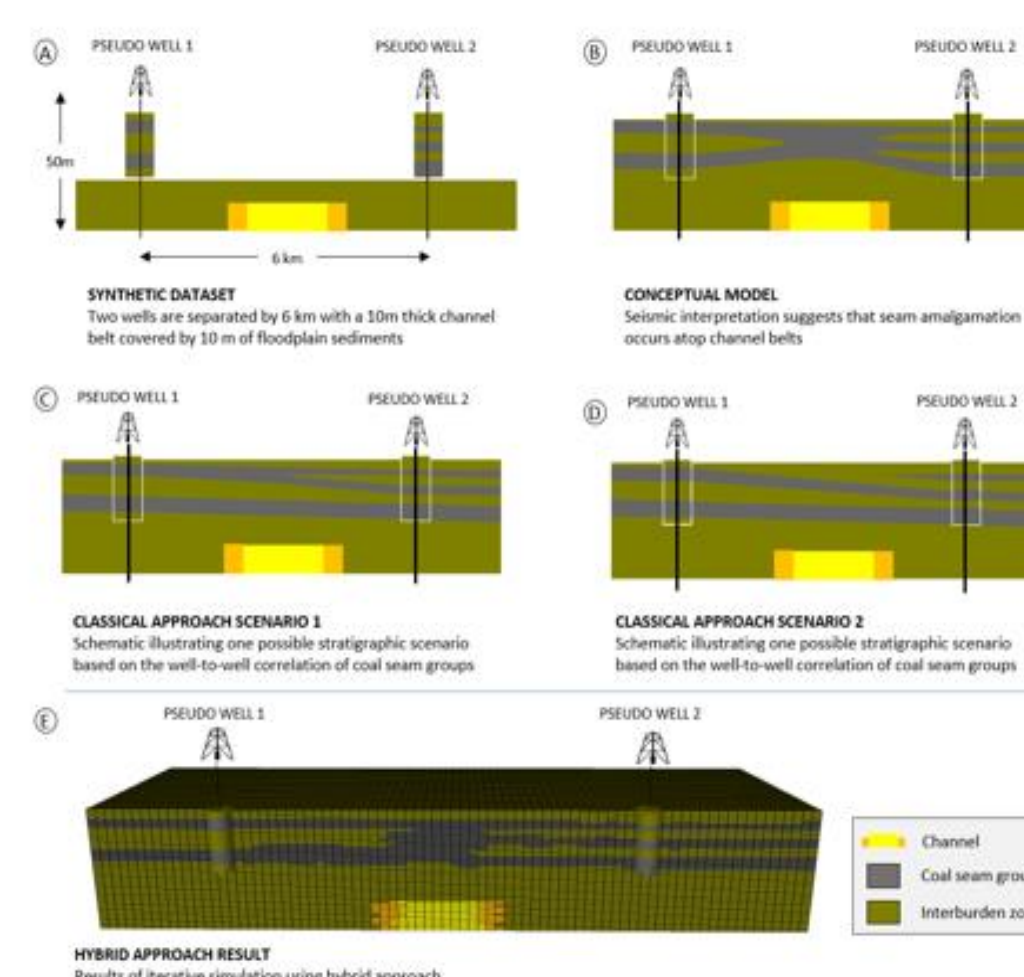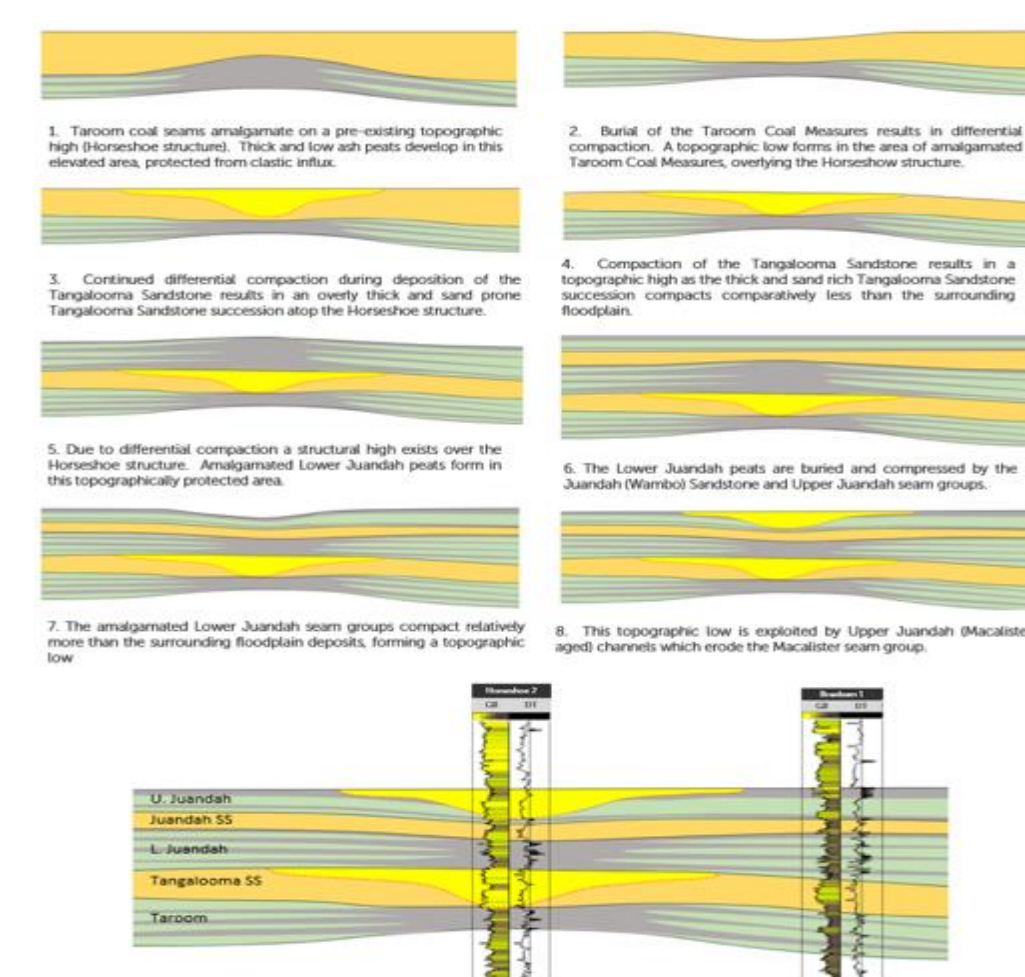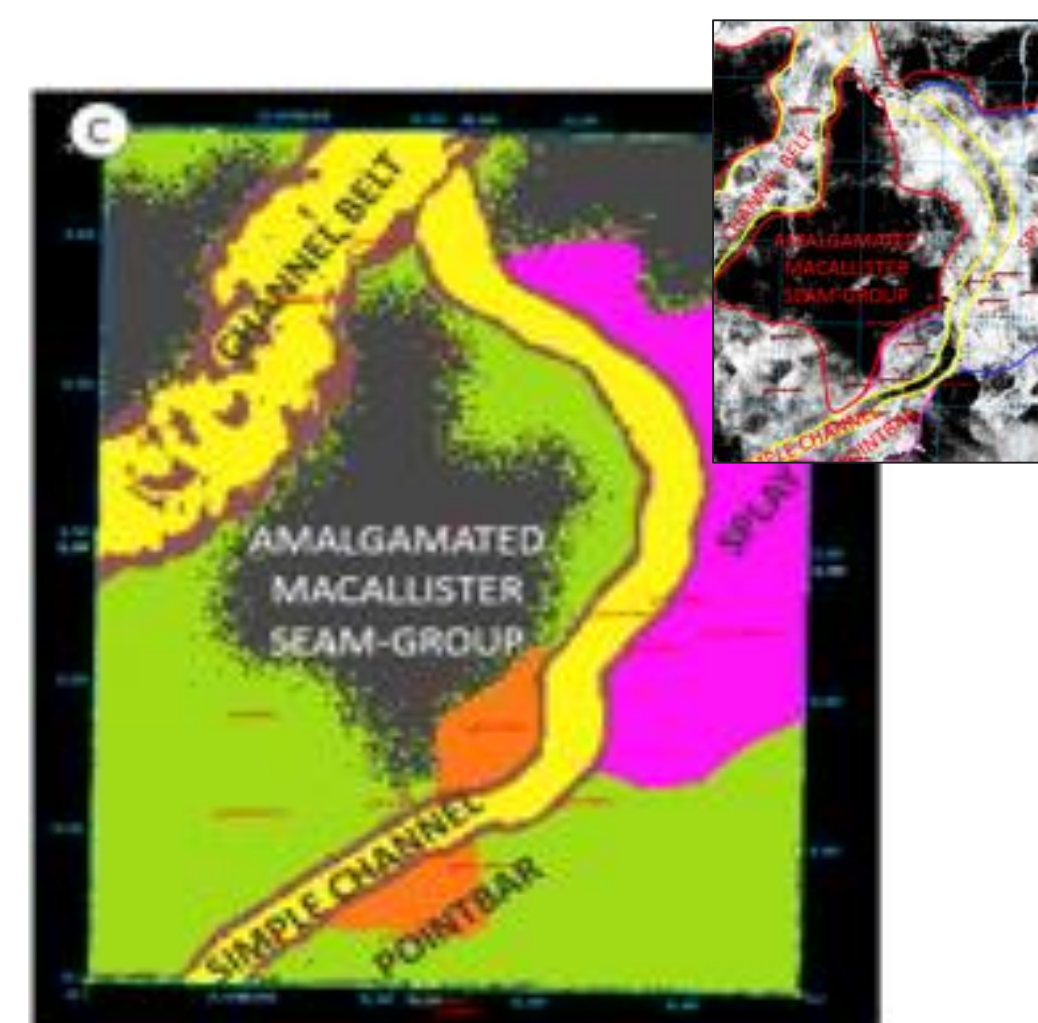
1. Defined geometry: Templates derived from seismic and well data that describe the 3D geometry and distribution of WSG architectural elements (Shields and Esterle 2015).

2. Depositional process: Interrogation of seismic and well data has revealed that compensational stacking is a key processes responsible for the WSG's complex alluvial organisation (Shields et al 2017A).

3. Computer routines: Development of a computer routine able to replicate the mechanics of compensational stacking and translate this understanding into numerical 3D grids (Shields et al. 2017B).

FACIES MODEL EVOLUTION
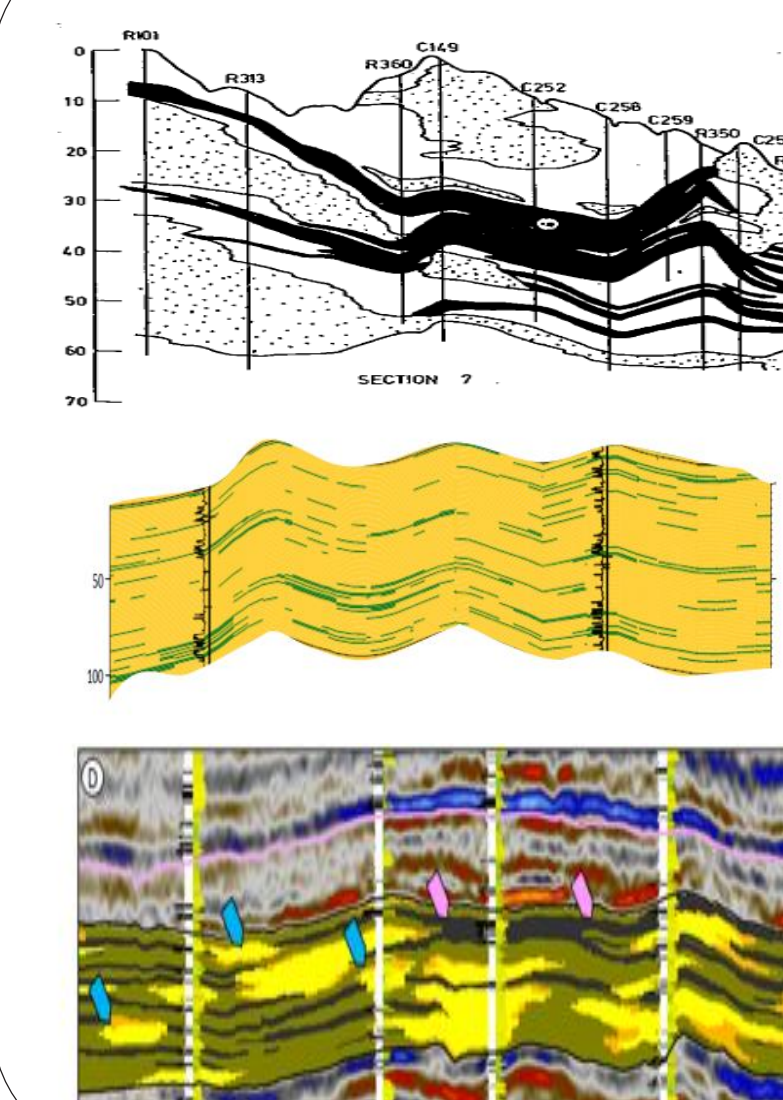
Observed field data:
WSG facies architecture as described from mining bores and exposures in the NE of the Surat Basin (Leblang et al. 1981). Complex organisation of coal bodies including seam amalgamation, bifurcation and wash out.

Previous generation of facies models:
An early WSG facies model constructed via existing geo-statistical algorithms. Absent are the complex features observed in the mining bore data. Not predictive with respect to flow-paths or reservoir continuity (Ryan et al. 2012)

Next generation facies models:
A facies model outcome generated using the newly developed PETREL plugin. This realization uses the 3D geometrical templates resolved from seismic, together with automata representing the mechanics of compensation stacking. Provides a more representative model outcome when compared to observed data (Shields et al. 2017B)

REFERENCES

- Shields, D., and Esterle, J., 2015. Regional insights into the sedimentary organisation of the Walloon Subgroup, Surat Basin. Australian Journal of Earth Sciences, 62 (8), 949-967.
- Shields, D., Bianchi, V., and Esterle, J., 2017A. A seismic based investigation into the geometry and controls on alluvial organisation in the Walloon Subgroup, Surat Basin, Queensland. Australian Journal of Earth Sciences, 64 (4), 455-469.
- Shields, D., Zhou, F., Buchannan, A., and Esterle, J., 2017B. Complementing coal seam gas facies modelling workflows with decompaction based processes. Journal of Marine and Petroleum Geoscience, 88, 155 -169.
- Leblang, G.M, Rayment, P.A. and Smyth, M., 1981. The Austinvale coal deposit - Wandoan: a palaeoenvironmental analysis. Coal Geology 1, 185-195.