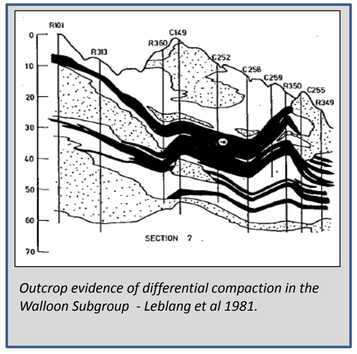
COMPLEMENTING COAL SEAM GAS FACIES MODELLING WORKFLOWS WITH DECOMPACTION BASED PROCESSES

Daren Shields, Fengde Zhou & Joan Esterle

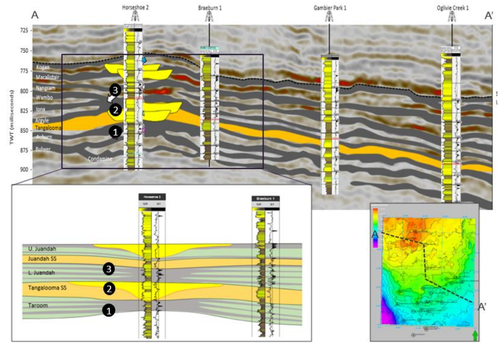
ABSTRACT

Published outcrop / highwall studies (eg. Yago 1996, LeBlang et al. 1981) describe the Walloon Subgroup (WSG) as a complex, heterolithic succession composed of lenticular coal layers in which well-to-well correlations are unreliable even at close well spacing. This complexity is due (in part) to differential compaction, which plays a key role in influencing the paleogeographic organisation of many alluvial environments. Despite this understanding the industry standard approach continues to use these ambiguous correlations to form the framework for most WSG reservoir models – a workflow which has remained largely unchanged over the past several decades. To address this limitation, a hybrid modelling workflow was developed which formalises the process of differential compaction into numerical rules which are used explicitly to condition traditional geostatistical facies modelling algorithms. Application of the workflow was tested in an area of the Surat Basin where the alluvial architecture of the Walloon Subgroup is known from 3D seismic. The hybrid geostatistical-forward modelling approach developed during this study was able to better reproduce the complex alluvial stacking patterns present within the Walloon Subgroup than traditional geostatistical approaches alone.



Outcrop evidence of differential compaction in the Walloon Subgroup - Leblang et al 1981.

COMPENSATIONAL STACKING IN THE WALLOON SUBGROUP



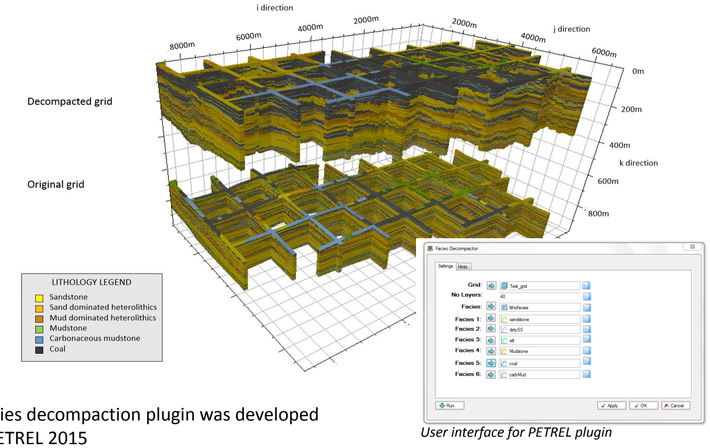
1. Development of an over-thickened amalgamated peat in a topographically elevated.

2. Subsequent burial of these peats, resulting in rapid compaction and inversion of the topographic high into a topographic low which attracts channels.

3. Once buried these channels compact less than adjacent floodplain sediments, thus once again develop in a topographic high area upon which amalgamated coals can once again form.

Within the study area, it was observed that the paleogeography of the WSG is not randomly organised, but rather a memory exists by which older elements appear to influence the position of younger ones. Seismic mapping demonstrates that channel belts display a tendency to preferentially overly areas of anomalously thick, amalgamated peat development.

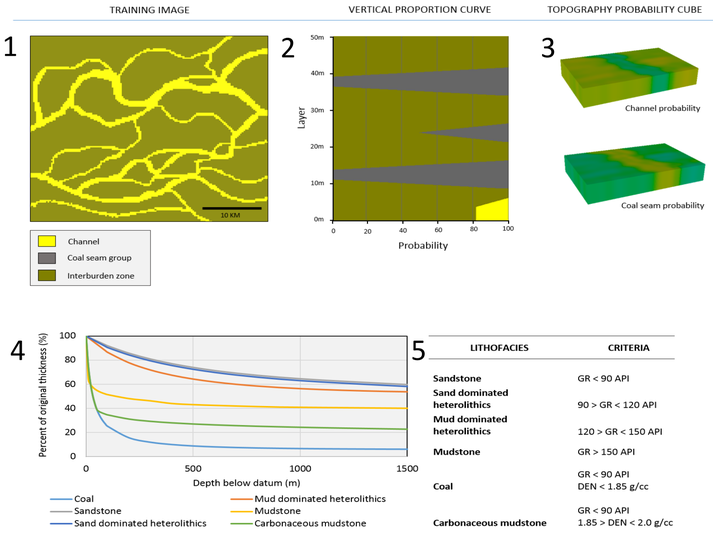
DECOMPACTION MODELLING



User interface for PETREL plugin

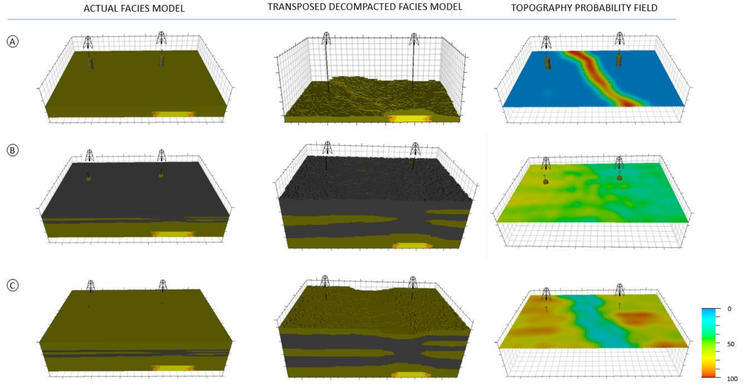
- A facies decompaction plugin was developed for PETREL 2015
- One use of this plugin is to create instantaneous decompacted models of the WSG to understand how topography evolved due to differential compaction on the alluvial plain upon which the WSG was deposited.
- These topography models can be coupled with traditional facies modelling algorithms to build facies models which are conditioned by automata representing the mechanics of differential compaction

MODELLING INPUTS



1. MPS training image
2. Vertical proportion curves
3. Spatial probability properties (representing decompacted topography)
4. Compaction curves for each modelled lithology
5. Palaeogeography and lithology facies blocked at the wells

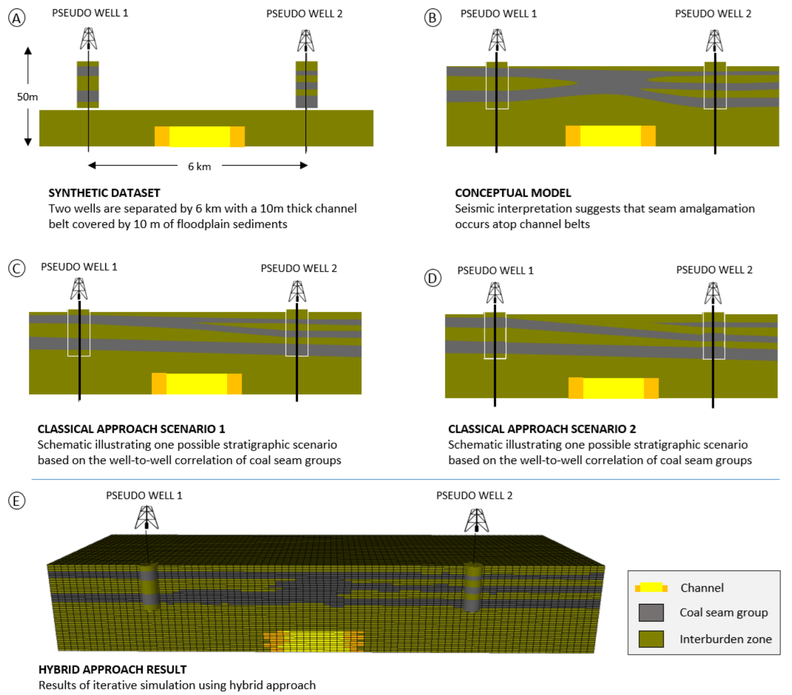
PROCESS VALIDATION



An experiment was designed to test the capability of the hybrid approach to replicate stacking patterns using automata approximating the mechanics of differential compaction. The synthetic dataset includes two wells located 6 km apart containing a 50 m thick peatmire – floodplain sequence representing the typical Lower Juandah succession A: 10 m thick channel facies is loaded by 10 m of floodplain sediments. The positive topographic feature overlying the channel is reflected as an area of high probability (red) for coal deposition by time B. B: Deposition of additional 20 m meters of coal and interburden alluvial facies by time B results in the reduction of the topographic feature overlying the channel. C: Deposition of additional 10 m of sediments results in topographic high overlying channel at beginning of time B to become inverted, hence will probably attract a second channel belt.

MODELLING RESULTS

A: The synthetic dataset includes two wells, separated by 6km. B: The conceptual model follows seismic and outcrop observations that coal seam amalgamation occurs a top channel belts. C & D: Classical approach scenarios based on possible well-to-well correlations. E: The hybrid model outcome honours both the measured data at the well as wells as the process of differential compaction.



CONCLUSION

Interrogation of models constructed using the current best-practices approach to CSG reservoir modelling suggests that these may not be able to reasonably represent the architecture of coal layers in complex successions such as the WSG. Should the geometric complexity of reservoir units be insufficiently captured within the facies model, the predicted flow structure of the resulting model may be compromised. This finding has led to the development of a modelling workflow in which the interaction between clastic and organic alluvial elements are captured via decompaction modelling. This workflow has been tested and demonstrated to be able to reproduce complex compaction driven alluvial stacking patterns which were observed in 3D seismic. The workflow can be either directly applied to model actual datasets or indirectly applied to create more representative 3D training images for later deployment via MPS.