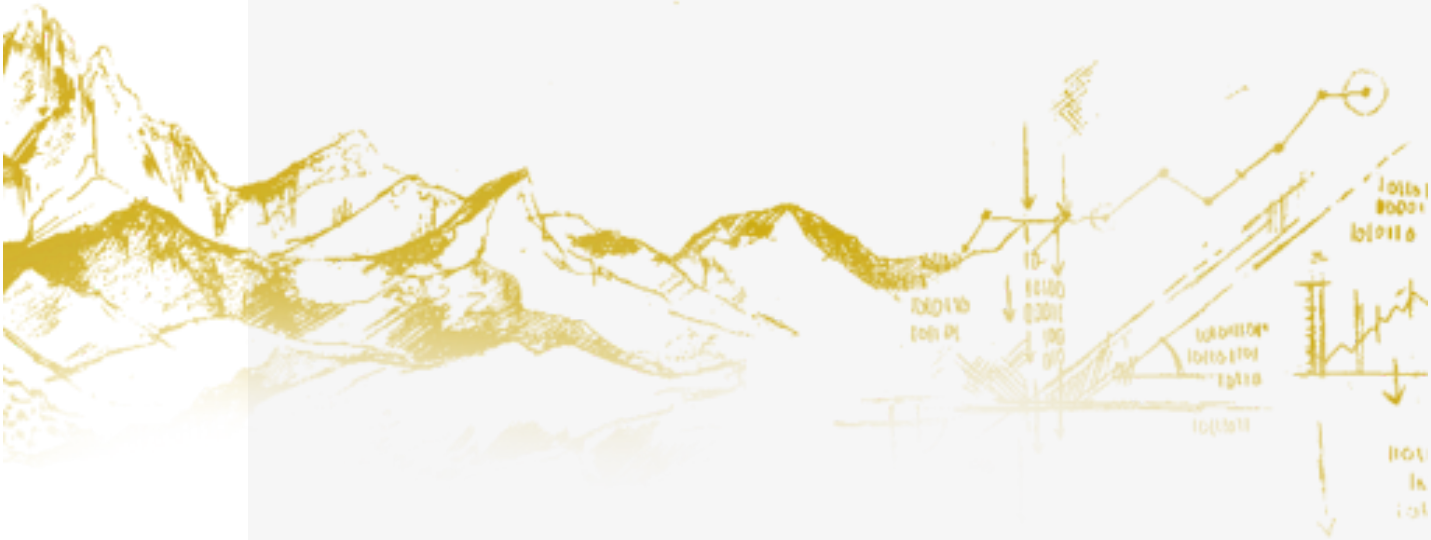
FACIES MODELLING WITH AVA CLASTICS - KAPUNI CASE STUDY



PREPARED AND PRESENTED BY

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SUMMARY

Challenge

Try to generate more realistic facies models for the Kapuni field, supported by high-quality analogue data.

Workflow

Query the FAKTS database in Ava Clastics, then parametrize the analogue data such that facies modelling algorithms can be informed and results expressed in Petrel.

Result

A series of geologically realistic, data-based, auditable facies models were produced and future areas of work have been identified.

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INTRODUCTION

Field history

The Kapuni field is located in the Taranaki Basin in New Zealand. Since the discovery of the field in 1959, 23 wells have been drilled. According to recent figures (New Zealand Petroleum & Minerals, 2014) the ultimate recoverable gas is around 2000BCF and 20MMBBL condensate. Most development wells have been drilled relatively close to the crest of the structure in the '60's-'70's.

Recent renewed drilling activity (2000's) has been concentrated at margins of the structure in order to delineate the extent of the structure and infill unproduced reserves. The field is currently subject to an ongoing redevelopment, with active infill drilling campaigns.

Geological evolution

Channel-sandstones, mudstones and coals of the Mangahewa Formation were deposited during the Middle to Late Eocene in the Taranaki Basin on the westside of New Zealand's North Island (Higgs et al., 2012a, 2012b). Until the early Cretaceous, Zealandia was part of an active margin of Gondwanaland.

During the late Cretaceous, back-arc spreading separated Zealandia from Australia. By the Paleogene, a passive margin along the Tasman Sea was established along which clastic wedges such as the Mangehewa Formation prograded westward (Figure 2; Strogan et al., 2011; Higgs et al., 2012a,b).

Inversion in Zealandia initiated 40 Ma. This started the current tectonic setting of New Zealand with convergent plate margins with a strike-slip transfer system in between (King, 2000). During this inversion, the trap of the Kapuni field was formed: a simple four-way closure, situated in the hanging wall of a substantial N-S orientated reverse fault with approximately up to 1km throw. Minor crestal faulting is also visible in the 3D seismic volume (Voggenreiter, 1993).

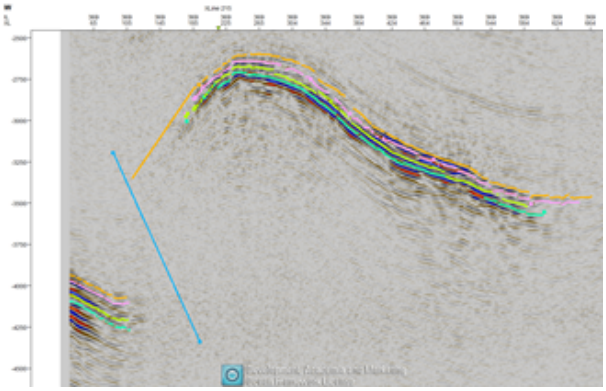

Figure 1 West-east oriented seismic section showing the main horizons and the fault

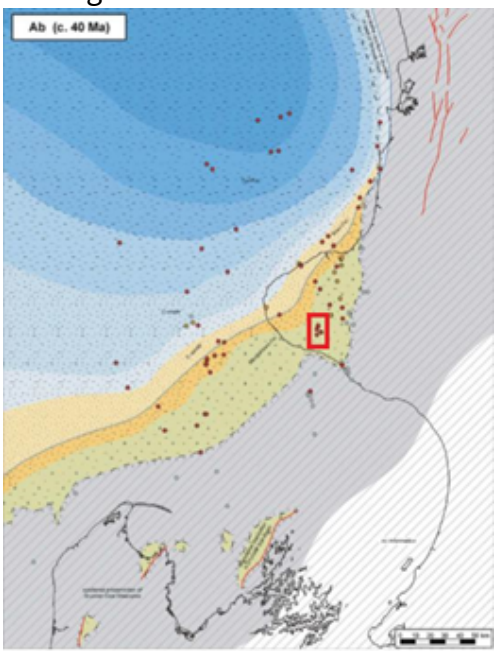

Figure 2. Palaeogeographic map of the Taranaki Basin (40 Ma) during Mangehewa Fm deposition. Kapuni Field is noted in red (modified after Strogan et al., 2011).

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DATASET AND METHODS

The dataset used in this case-study consists of a 3D seismic cube and 18 wells, all publicly available through the Petroleum Exploration Data Pack of the New Zealand Petroleum & Minerals department.

In the 3D seismic cube, the main reservoir interval of the Eocene lower delta plain deposits of the Mangehewa Formation are readily recognized due to the presence of coal measures with a strong impedance contrast. This results in bright, but over larger distances discontinuous reflectors in the seismic cube. Some potential channel fills are visible in the interval of bright reflectors. Below the bright reflectors, seismic imaging of the lower half of the reservoir interval is poor. Four reflectors have been correlated. The top reflector has been used as the top reservoir horizon.

There are 18 publicly released wells with wireline log data. Core descriptions/photographs of 5 wells have been used for calibration of the wireline logs. Facies are interpreted mainly based on the gamma ray (GR), neutron porosity (NEU) and bulk density (DEN) logs. Spontaneous potential (SP) and resistivity (RES) have been used to a lesser extent. A simple facies scheme has been used based on Higgs et al. (2012b).

There are 4 facies with distinct log signatures:

1. Coals: Extremely high neutron porosity (>0.5), extremely low bulk density (<2 g/cc), low gamma ray (~50 API).
2. (Overbank) mudstones: High gamma ray (>85 API), high neutron porosity (~0.18-0.35), high bulk density (~2.55-2.8 g/cc).
3. (Channel) sandstones: Intermediate variable gamma ray (~50-95 API), low neutron porosity (~0.05-0.18), low bulk density (~2.4-2.55 g/cc), negative spontaneous potential.
4. (Overbank) sandstones: Similar to channel sandstones, but thinner (<2m).

The overall interpretation for the Mangehewa is Isolated fluvial sandstones deposited on a lower delta plain.

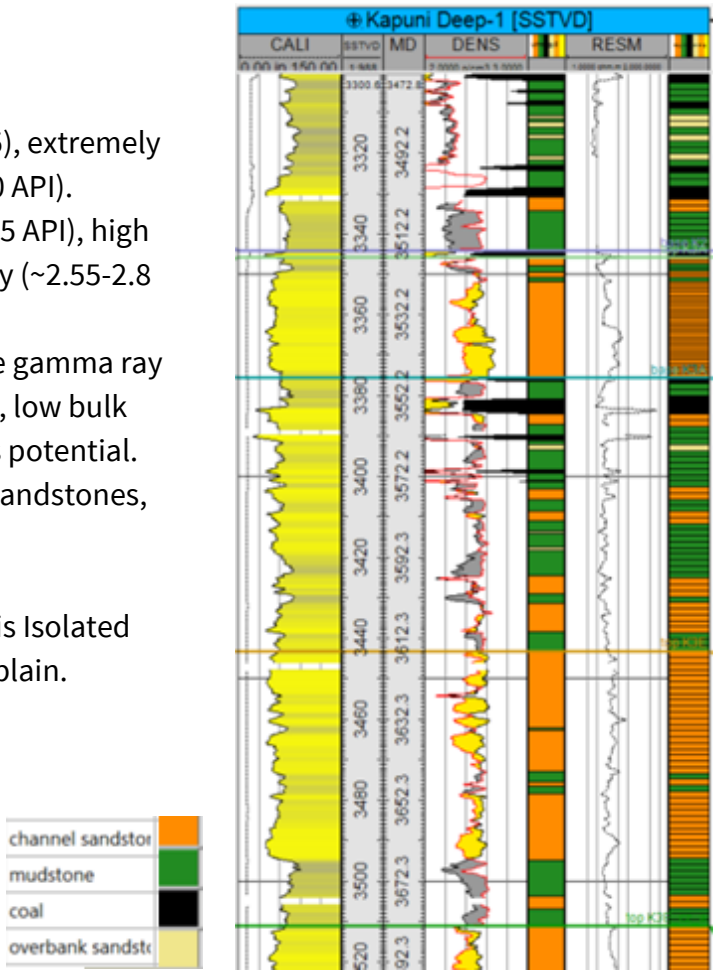

Figure 3 Wireline log data, facies interpretation and upscaled cells from the Kapuni Deep-1 well

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FACIES MODELLING OF DEPOSITIONAL ELEMENTS

Using the interpretation of isolated fluvial channels within a lower delta plain setting, it is possible to start exploring the expected proportions of sand versus shale, and also the expected geometries in this depositional environment.

Unsupported facies modelling at the Depositional element scale

For comparison, the Object-based modelling algorithm in Petrel was executed using the default settings. The results are shown below in Figure 5 and are, as expected, fairly unrealistic. In this case, there are relatively high thickness to width ratios.

FAKTS-informed facies modelling at the Depositional element scale

In contrast to the uninformed version, an improvement in the output from the Object-based modelling algorithm in Petrel is generated using data derived from FAKTS, based on two coastal plain Depositional Concepts, one slightly more humid than the other. The results for both cases are shown below in Figure 6 and in both cases show more realistic thickness/width ratios and sinuousities. In both cases the proportion of channel-complexes is around 25-30%.

Figure 5: Plan, Section and 3D views of the facies model generated using the defaults for the OBM algorithm

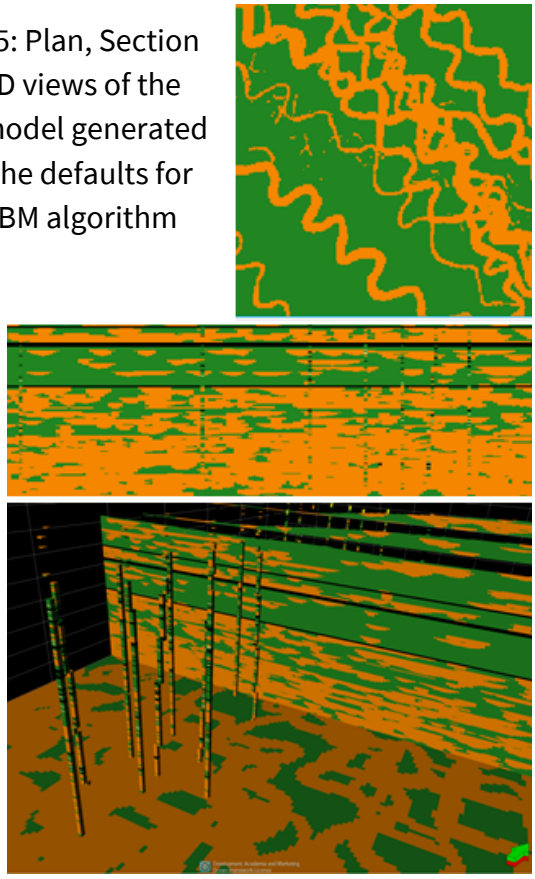
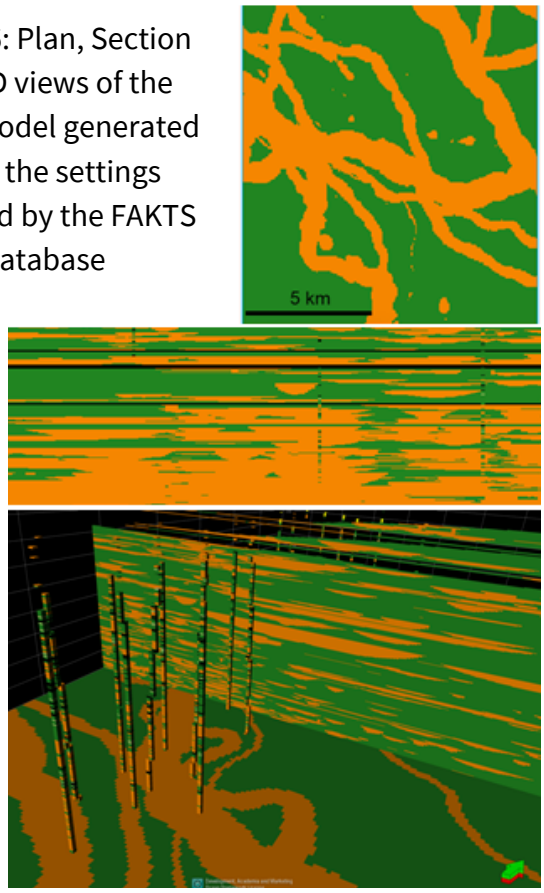


Figure 6: Plan, Section and 3D views of the facies model generated using the settings informed by the FAKTS database



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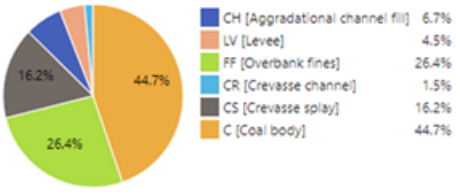
FACIES MODELLING OF ARCHITECTURAL ELEMENTS

As more data becomes available for a given asset, it is often necessary to model at a finer scale, such as the architectural element scale. As FAKTS contains data from depositional to facies scale it is possible to investigate the expected proportions and geometries at the architectural element scale. As shown in Figure 7 some of the following facies are expected: coals, aggradational channel fills, crevasse splays and overbank fines, which is consistent with the observations from the wells.

Figure 7: Proportions for Coastal plain areas from FAKTS



Results from FAKTS-supported modelling

Results from three simple approaches for utilising existing algorithms such as Object-Based Modelling (OBM) and Sequential Indicator Simulation (SIS), to incorporate the geometries contained within FAKTS, shown in Figure 8.

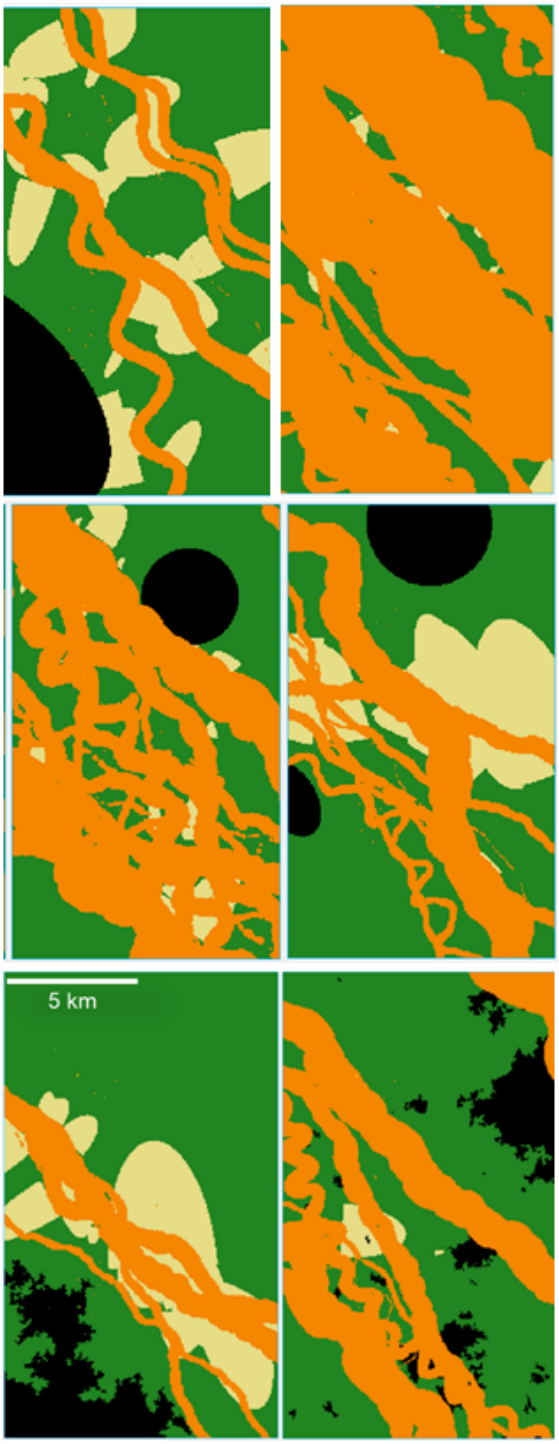
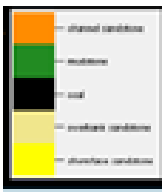


Figure 8: Results from FAKTS-informed workflows
(A) FAKTS-supported modelling with OBM
• Coals are first modelled as ellipses
• Channels are modelled avoiding coal bodies using a vector field
• Crevasse splays (quarter ellipses) originate from channel- belts at the point of highest curvature
(B) FAKTS-supported modelling with OBM
• Channels are modelled first
• Coals bodies are modeled as ellipses away from channels (using object distance), and crevasse splays originate from channel-belts at point of highest curvature
(C) FAKTS-supported modelling with OBM/SIS
• Coals are modelled first using Sequential Indicator Simulation (SIS) (with either proportions per zone or a depth trend)
• Channels replace all other facies
• Crevasse splays originate from channel-belts at point of highest curvature



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DISCUSSION

Direct incorporation and application of analogue data offers the ability to :

- Replicate the same workflow using alternative facies modelling algorithms
- Compare the impact of different scenarios on estimated volume
- Explore the impact of different scenarios on lateral and vertical connectivity

Conclusions

Through a structured approach to the querying and then applying high quality analogues taken from the FAKTS database, it is possible to improve the modelled 3D facies distributions on both the depositional element and architectural element scale, for the Kapuni field. In particular, the representation of the coals and overbank sandstones at the architectural scale is more realistic.

Combined with additional geological insight from geoscientists at the depositional concept(s) definition stage, the expected result is an apparent improvement in the standard of fluvial facies models in mainstream software platforms like Petrel, however this approach would benefit from the availability of improved facies modelling algorithms, which can accommodate for example, highly sinuous channel geometries.

By directly incorporating observable geological architectures into 3D facies models, it is possible to begin assessing the impact on both the overall and distribution of pay within the reservoir interval, leading to improved assessment of the economic viability and producibility of the Mangehewa Formation. Further work to investigate the difference in dynamic response between FAKTS-informed and uninformed property distributions would be a useful next step for Kapuni.

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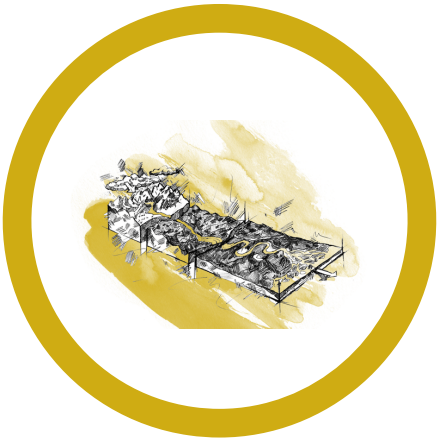
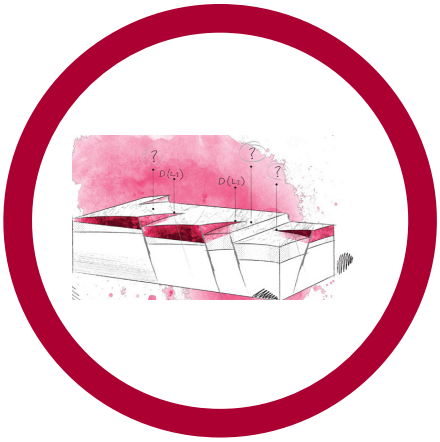


ava clastics

Analogue databases

ava saturation

Volumetric uncertainty



ava structure

Compartmentalisation

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