[PS]Exploration Risk Assessment Using Forward Stratigraphic Modelling: Flemish Pass Basin, NL, Canada*

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Abstract

The Flemish Pass Basin recently gained attraction with the oil discoveries made in 2009 (Mizzen 0-16) and 2013 (Bay du Nord C-78). The area has also just closed its first scheduled land sale NL15_01EN in November 2015. This study reports an exploration risk assessment method based on a forward stratigraphic model capable of quantifying the reservoir, seal and source rock presence and effectiveness. A comprehensive stratigraphic / paleoenvironment interpretation of the Flemish Pass Basin serves as the basis to the construction of Gross Depositional Environment (GDE) maps characterizing paleoenvironments at time of deposition providing constraints on the paleobathymetry. When coupled with seismic thickness maps, these maps allow computing of accommodation maps (creation of available space for sedimentation), which are the main input for the numerical model. A forward stratigraphic simulation was performed using DionisoFlow™ in order to characterize the 3D sedimentary architecture of the basin and quantify the sedimentary volumes at the basin scale. This modelling was performed encompassing source rock, reservoir and seal, in sequential time steps of 0.1 Ma with a 4×4 km grid. For each time step, three main environmental parameters were taken into account: the accommodation (subsidence and eustasy); the sediment supply (with in situ erosion and drainage basins) and macro-scale sediment transport laws (equation of diffusion). The 890 layer model is calibrated to respect lithologies at wells, seismic thickness and seismic stratigraphic architecture. Based on the 3D volume reservoir, seal and source rock maps are calculated to provide quantified constraints on their presence and effectiveness. The reservoir maps are generated using cut off on net sand, the presence and cumulated thickness of individual sand beds thicker than 5 m and thicker than 20 m. The seal map effectiveness is generated by characterizing net shale maps with continuous layers of at least 5, 10 and 20 m. Source rock maps are generated by combining shale prone areas (net shale) with that of low water flow energy calibrated to TOC measurements at wells. Final exploration risks maps are obtained by combining reservoir, seal and source rock maps. The use of DionisoFlow™ forward stratigraphic model grid allows spatially constrained and quantified exploration risk maps to be addressed at the model cell scale in poorly constrained exploration areas.

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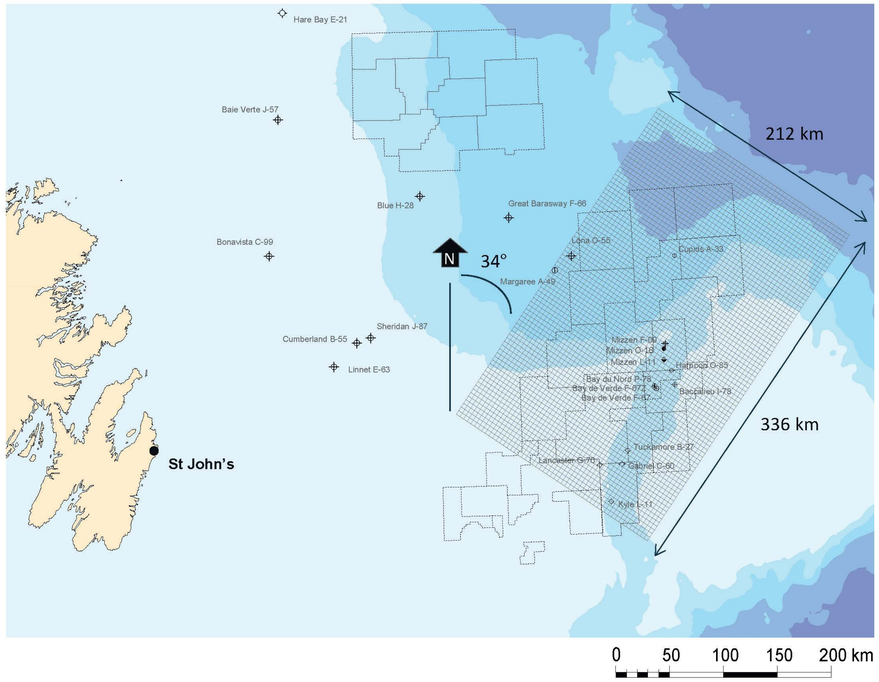
Objectives

In exploration, constraints on play elements are rare and spatially scattered resulting in loose qualitative Common Risk Segment (CRS) mapping.

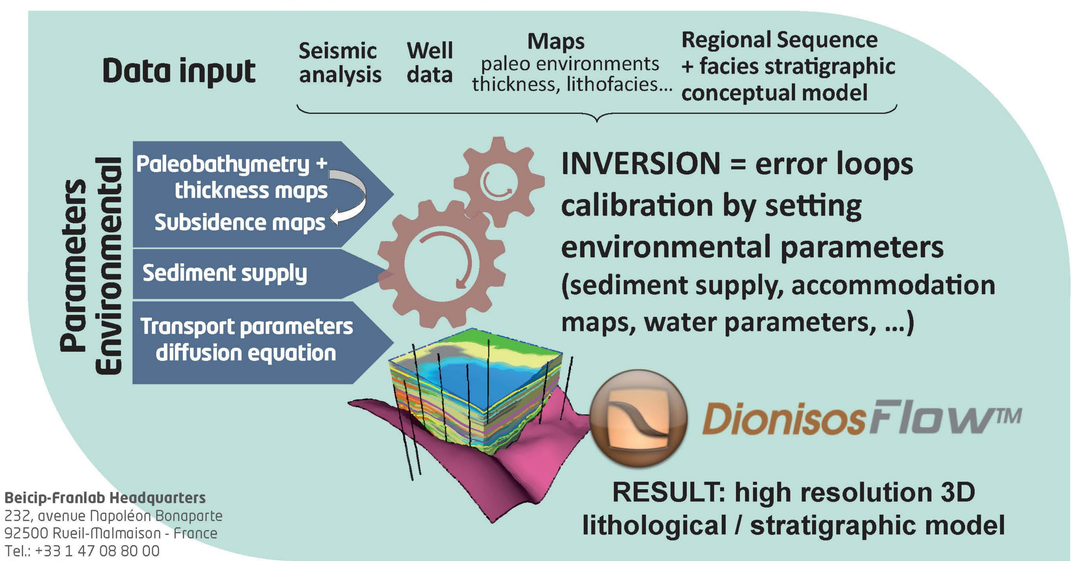
We present here a methodology to quantify play element presence and effectiveness through a calibrated forward stratigraphic model enabling highest spatial resolution and quantified risk assessment through CRS mapping.



Context

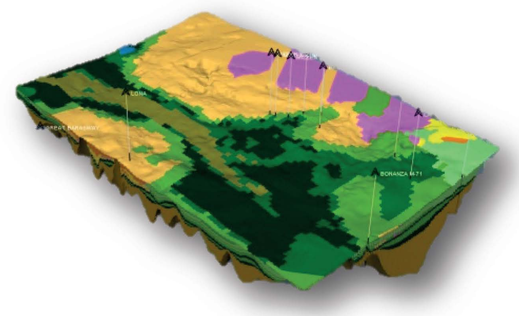
The Eastern Newfoundland Region represents part of the North Atlantic Mesozoic rift system which includes the Jeanne d'Arc, Orphan and Flemish Pass basins. In January 2015, Nalcor Energy and Beicip-Franlab began the resource assessment of the Flemish Pass area and the study scope was set to include the NL01-EN sector (2015 license round area) and surrounding acreage for completeness.
As part of the study, a full 4D DionisosFlow model was initiated to predict the reservoir, seal and potential source rock presence and efficiency. The simulation time ranges from the base of Tithonian (151 Ma) to the base of Tertiary erosion (65 Ma). The time step used in the simulation is 0.1 Ma. The final 3D cube model is comprised of 890 layers.

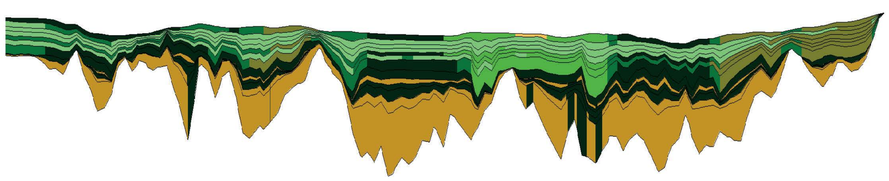
Modeling principles



Full model grid results

Top Tithonian Play model grid in terms of litho-facies (see next page) is displaying continental sand on paleohighs feeding distal turbidites complexes. This play was proven successful in 2009 by the Mizzen discovery and the Bay du Nord discovery in 2013).





Resource Assesment available here!

http://goo.gl/VFYYdy

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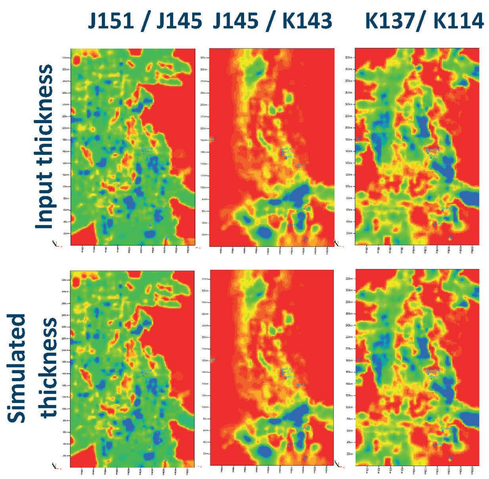
Calibration

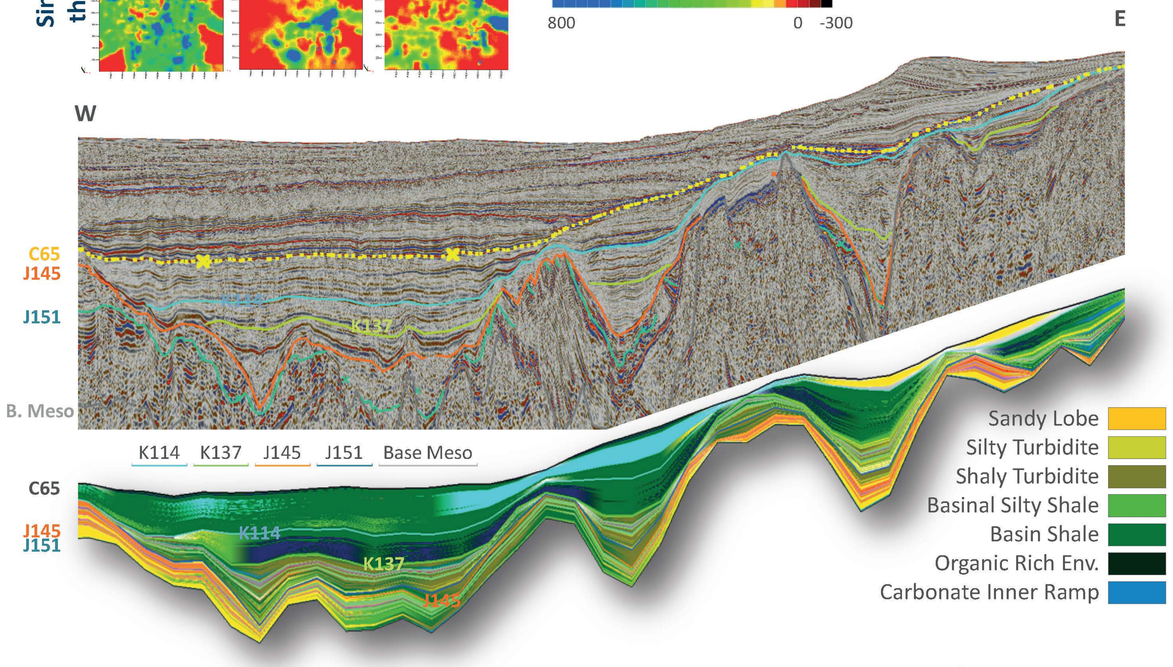
A step-by step setting of each time interval:



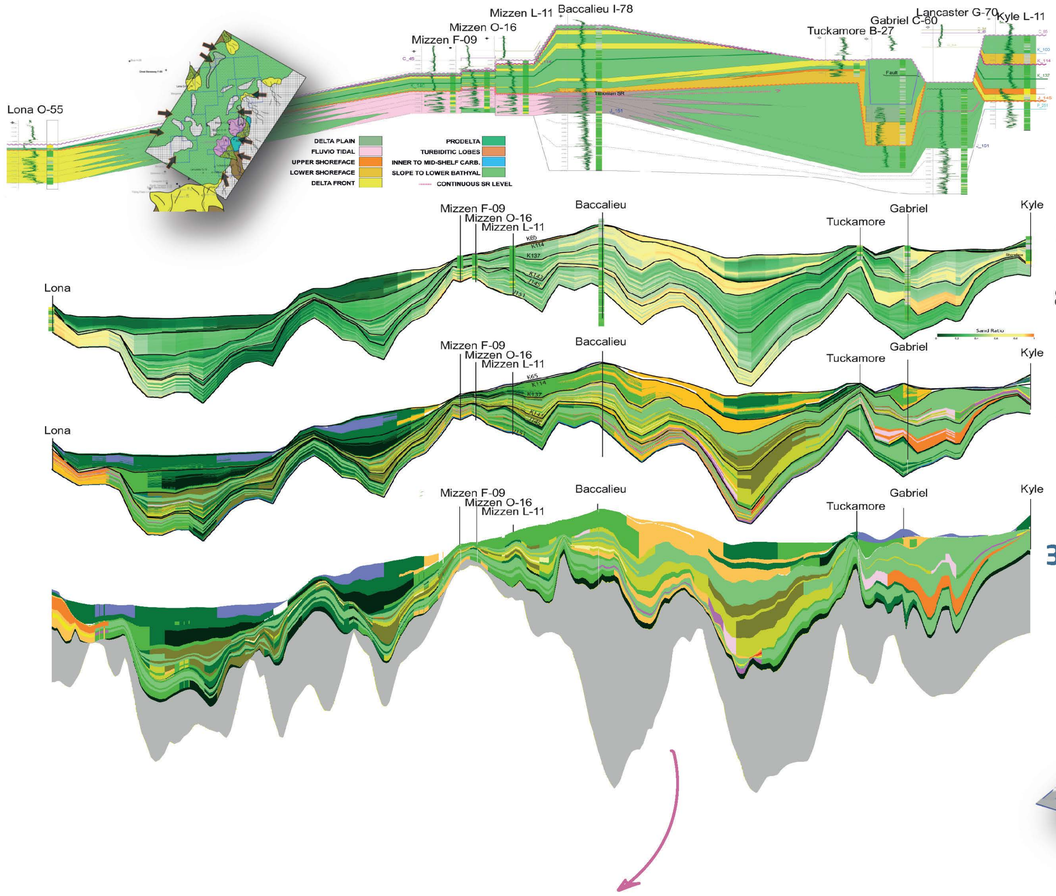
Seismic thickness

Markers & Volume of shale at 9 well locations.

Seismic stratigraphy, specific geobodies & stratal terminations



From sedimentology to modeling

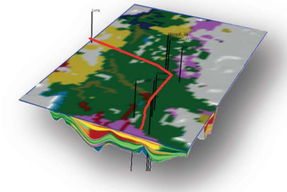


Initial stratigraphic interpretation
(geology at wells & GDE mapping)

3D Forward Stratigraphic Model
(sand proportion over 890 layers; 4x4 km grid)

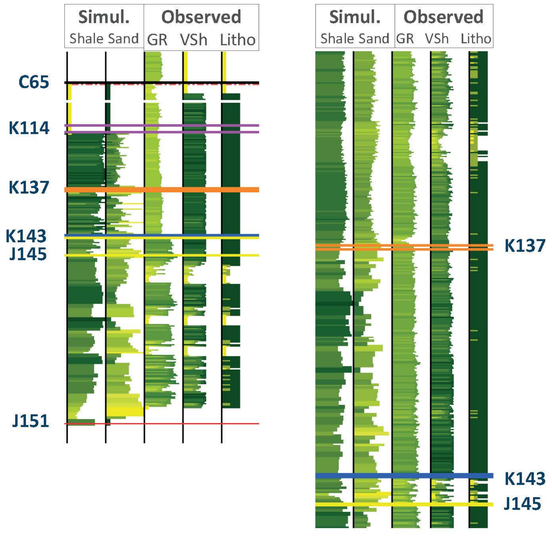
3D Forward Stratigraphic Model
Facies distribution

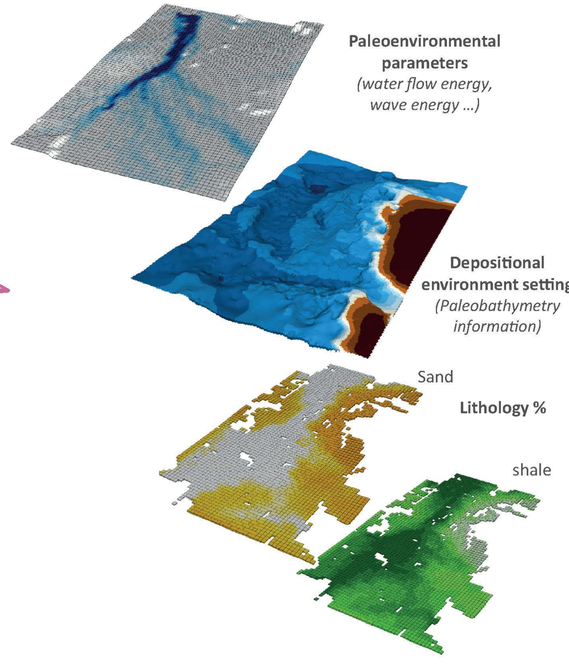
3D Petroleum System model
23 upscaled facies layers (in 1x1km grid)



Lithological map building

Mizzen F-09 Baccalieu I-78



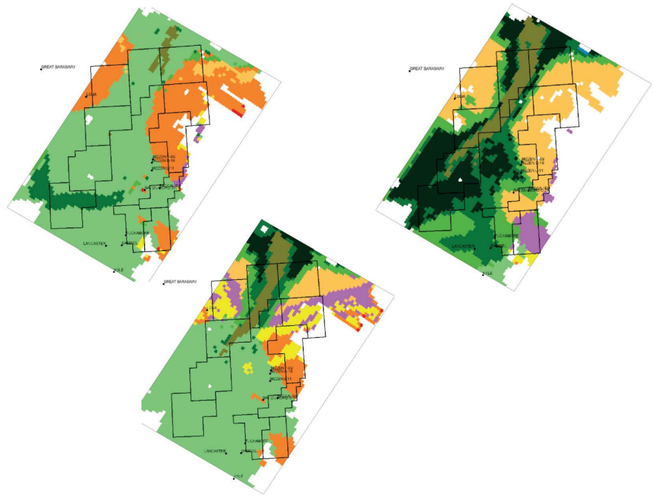


Lithofacies discrimination

- Sandy Lobe
- Silty Turbidite
- Shaly Turbidite
- Basinal Silty Shale
- Basin Shale
- Organic Rich Env.
- Carbonate Inner Ramp
- Continental Sandy
- Shaly Alluvial Plain
- Upper Shorface
- Lower Shorface
- Sandy Channel Mouth
- Delta Front
- Sandy Turbidite Channel

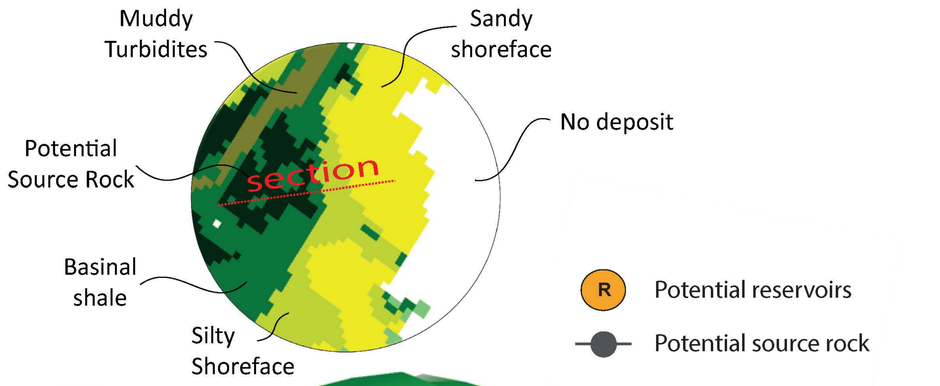
17 Litho-Facies

Lithofacies map building for petroleum system modeling

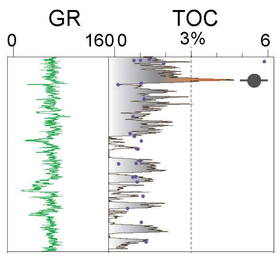


One play definition

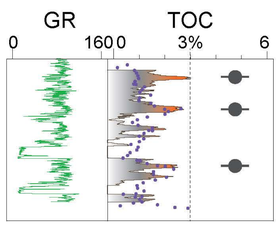
Facies map & section



Baccalieu I-78



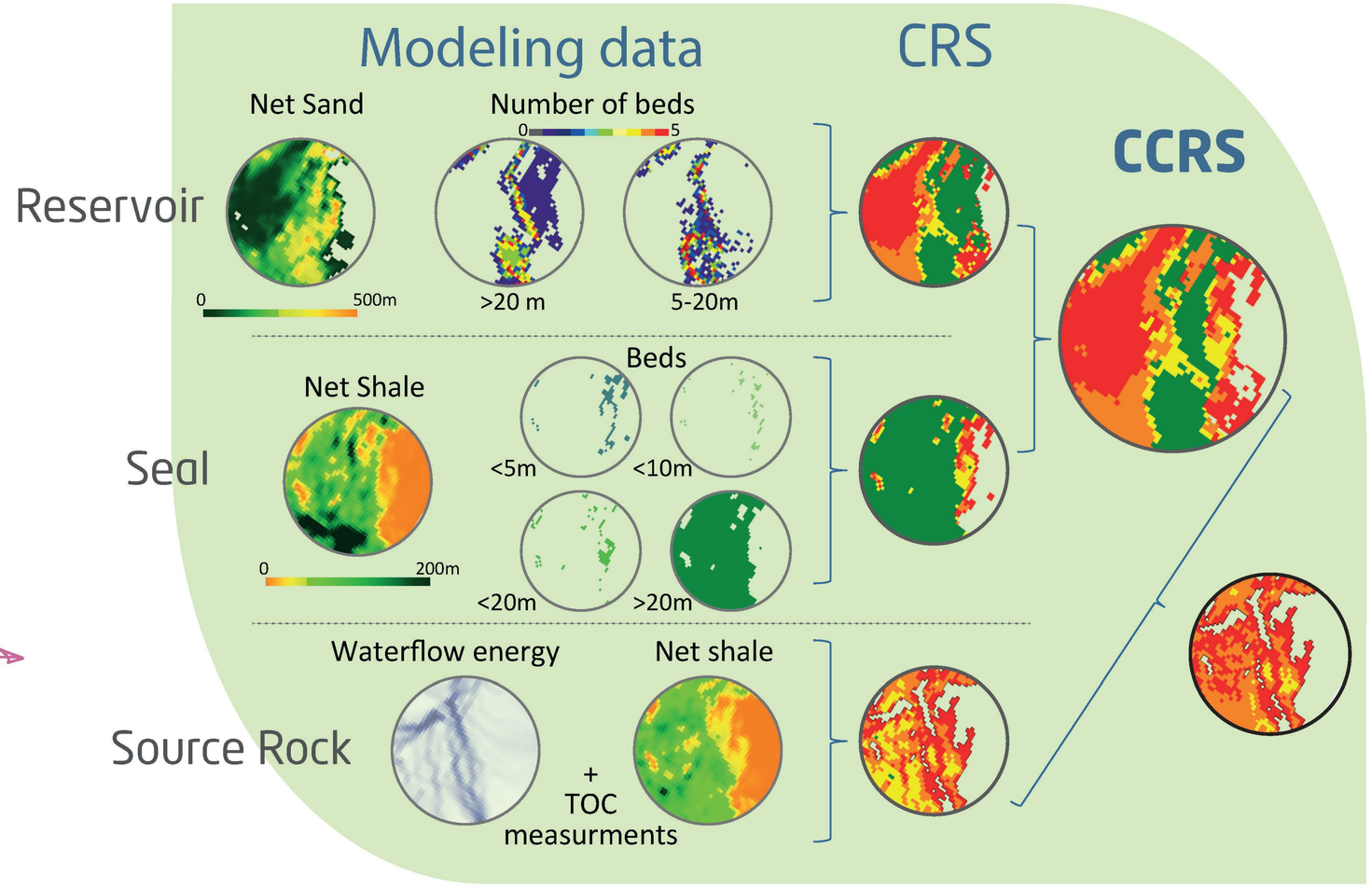
Mizzen L-11



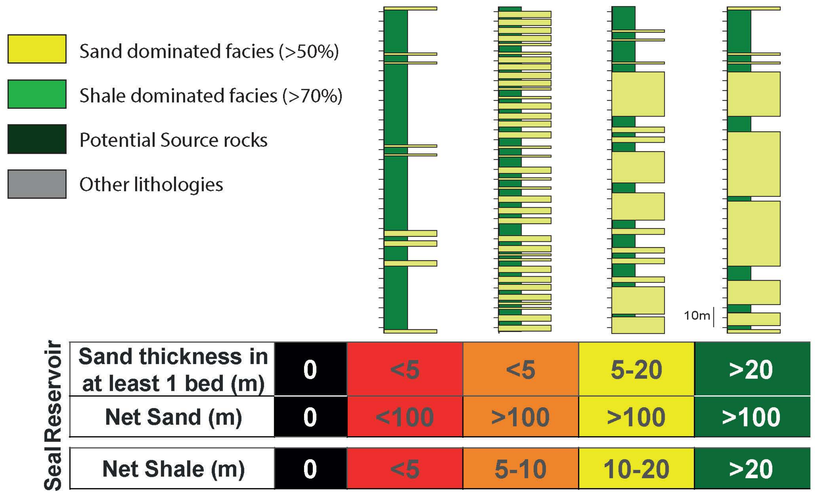
TOC calculated using Carbolog method

Play quality assessment

The play is defined over 80 time layers (0.1 Myr each) attaining a maximum of 500m of thickness in the upper Tithonian. Reservoir and seal levels are heterogeneous laterally in terms of lithologies. A Source Rock is present laterally to the reservoir and is sampled by nearby TOC measurements from two wells in proximal and distal areas.
The following CRS maps illustrate the exploration risk of this level in this area.



CRS coding



Conclusions

The use of DionisosFlow™ forward stratigraphic model allows spatially constrained and quantified exploration risk maps to be addressed at the model cell scale.

The discrimination of the Net sand and shale thickness allows a better assessment of the geological risks.

This approach considerably derisks plays found in the Flemish Pass Basin where cumulative resources were estimated to 12 Bbbl in the NL15_01EN licence round.