

Pcube+ - high resolution horizon update by prestack inversion

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Outline

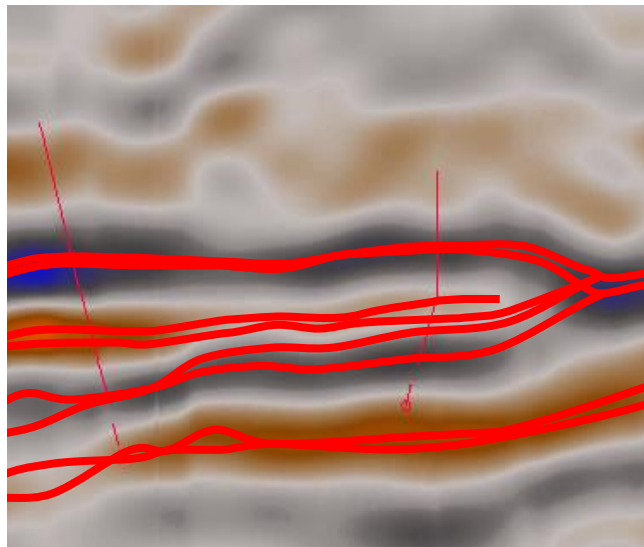
- Motivation
- Simplified example – thin gas sand – achieving a detailed interpretation
 - Classical detuning
 - Rock physics inversion walk-through
- Real case with several layers in tuning (Statfjord East flank)
- Concluding remarks

Motivation – horizon update by inversion

Horizons are widely used

- Volumetrics
- Well prognoses
- Geomodels

One of the most important deliveries from geophysics.



Horizon interpretation - customary practice:

Pick one substack.

Interpret horizons in max peak and max trough.

Thin layers - tuning and AVO issues:

Real layer boundaries not in max peak or max trough
Amplitudes and AVO carry information – not used.

Horizons update by prestack inversion:

Using rock physics knowledge.

Moving horizons away from peaks and troughs.
Quantifying the uncertainty.

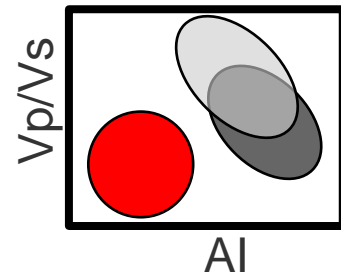
Resulting in:

Better volumetrics.

More accurate well placement.

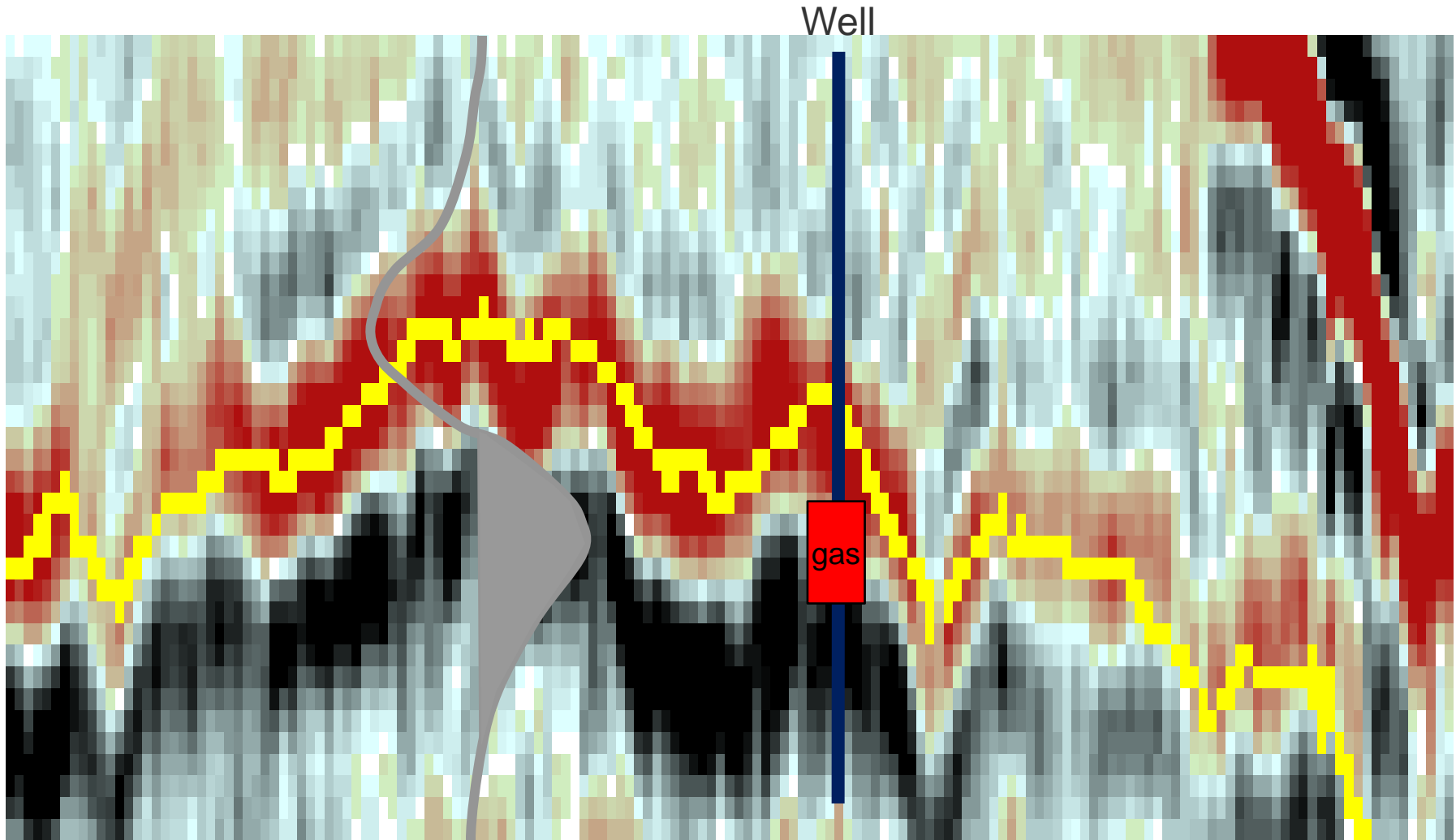
Better understanding of uncertainty.

Horizon consistency check by prestack data.

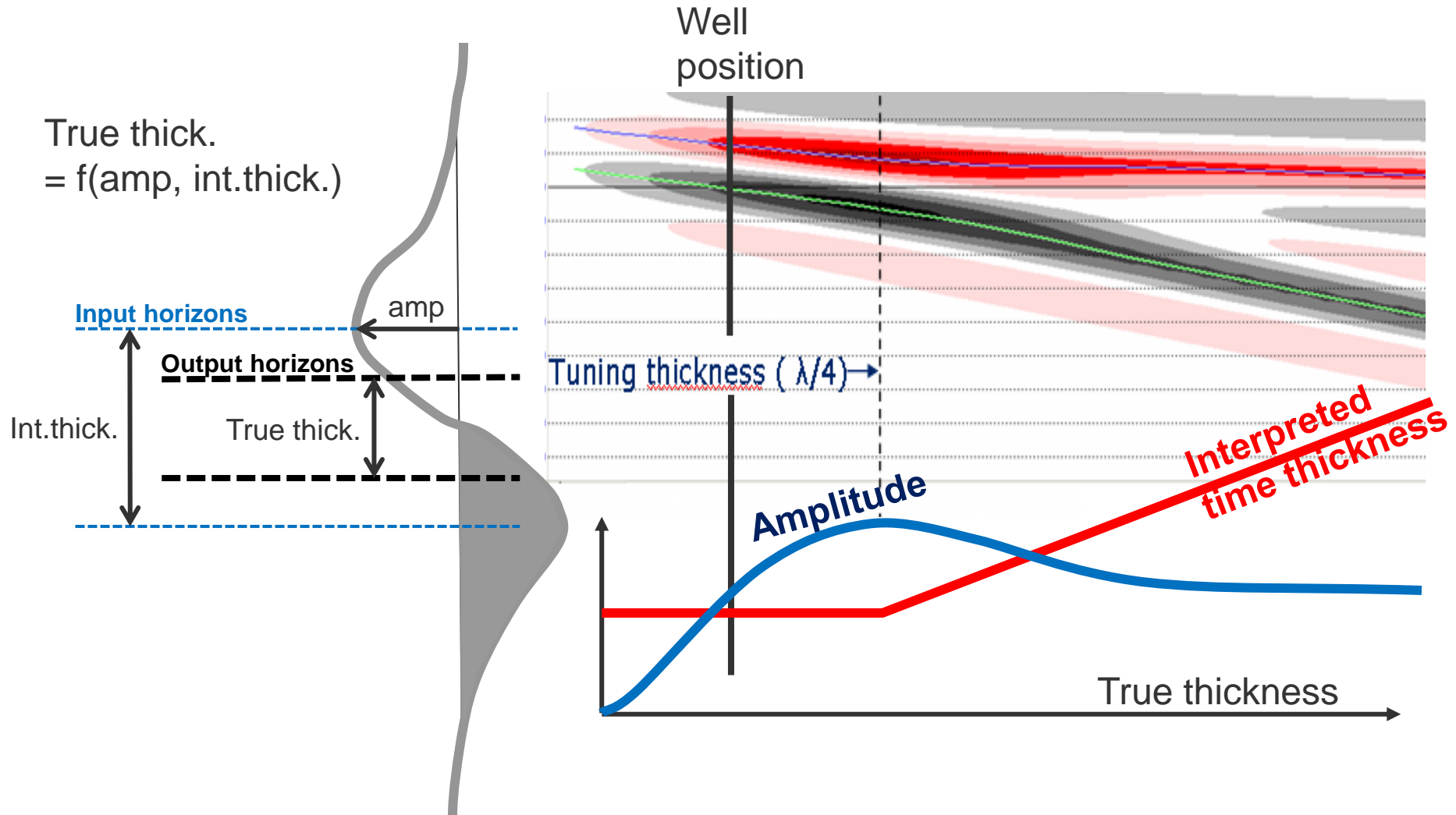


Simple case - Thin gas sand in tuning

How to achieve a more detailed horizon placement



The quick and easy way – detuning

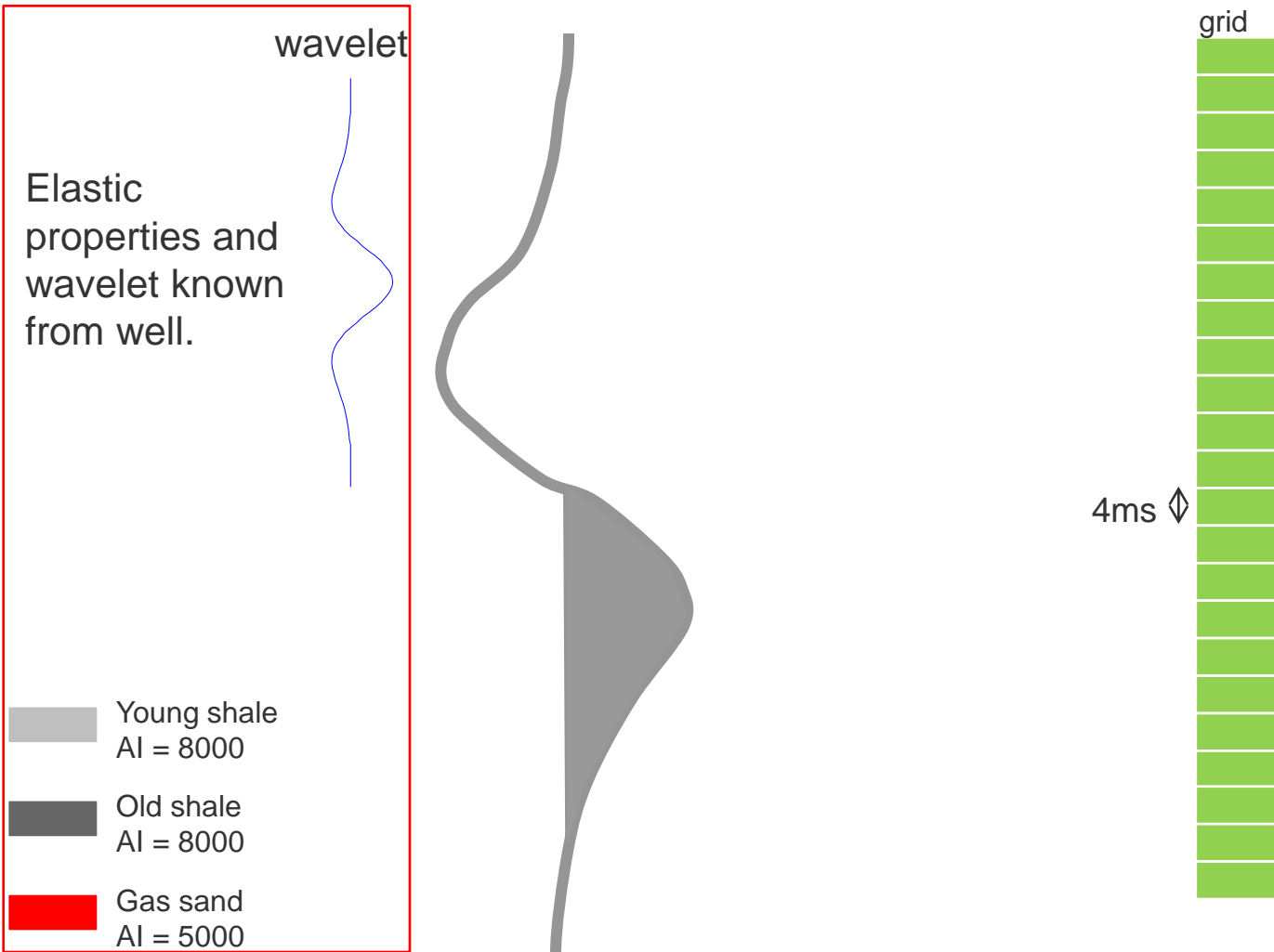


Knowledge of properties and assumption of blocky sand enables detailed horizon prediction below tuning thickness

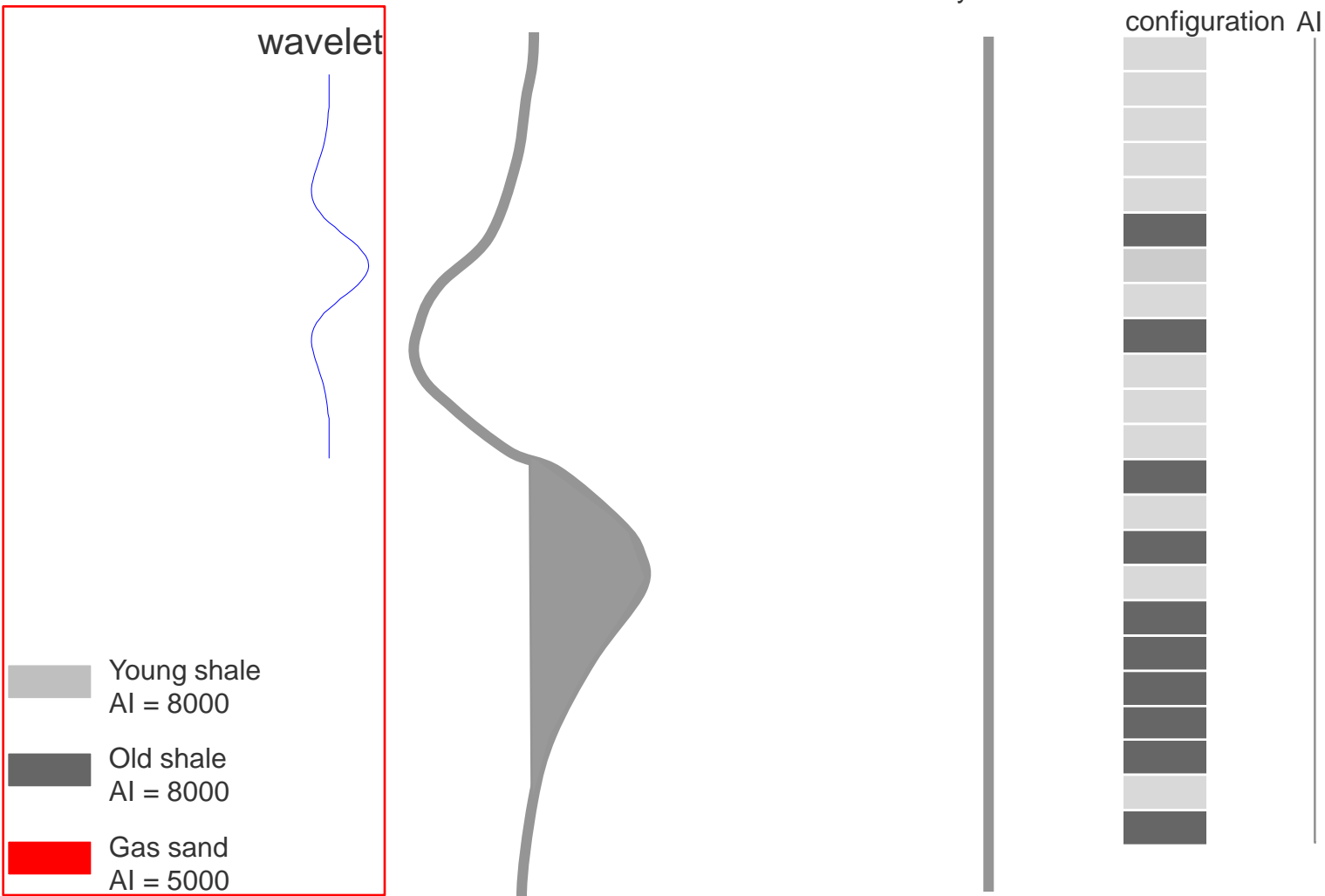


Simple case - Rock physics inversion

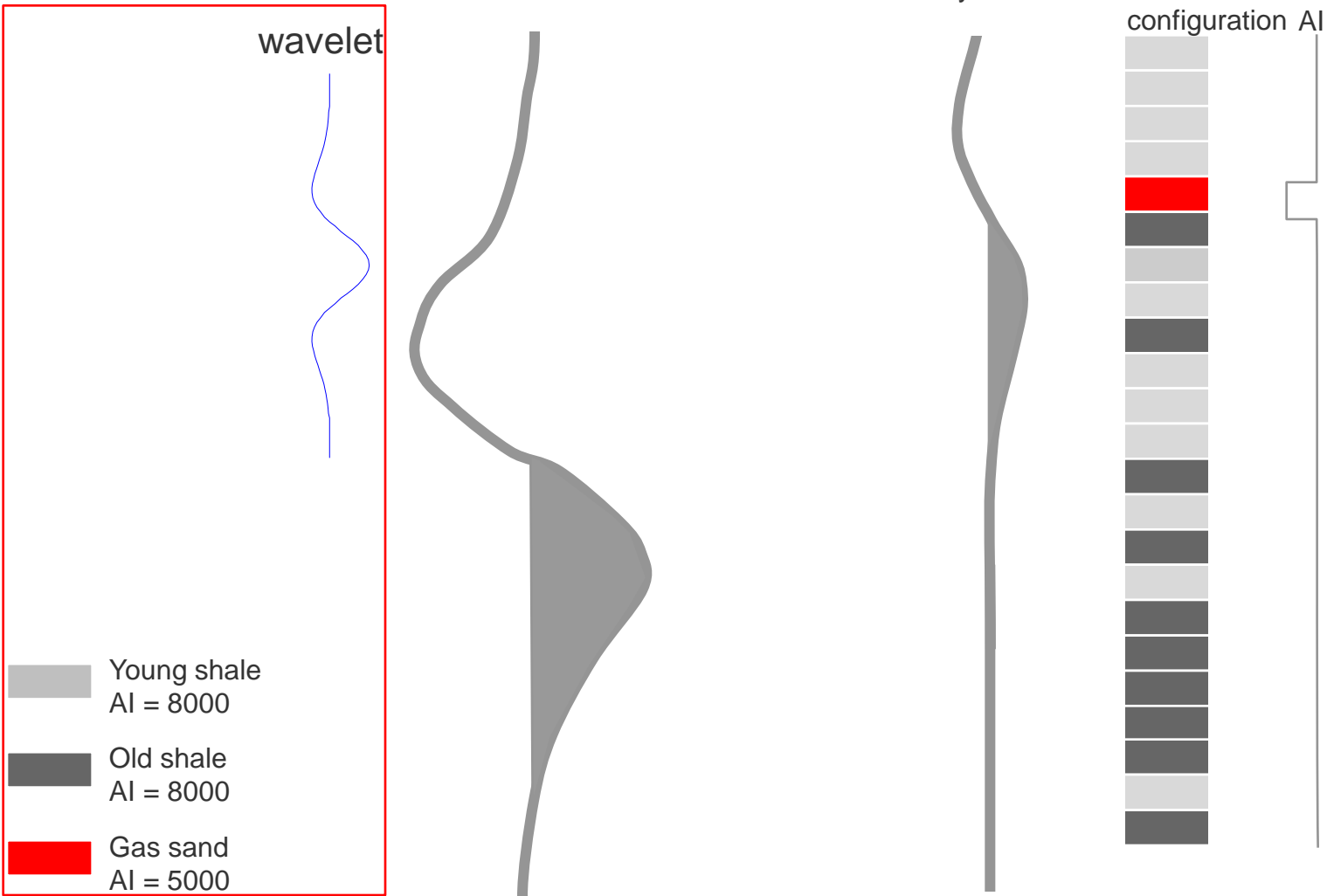
AI and near stack only. 3 possible Lithology fluid classes (LFC's)



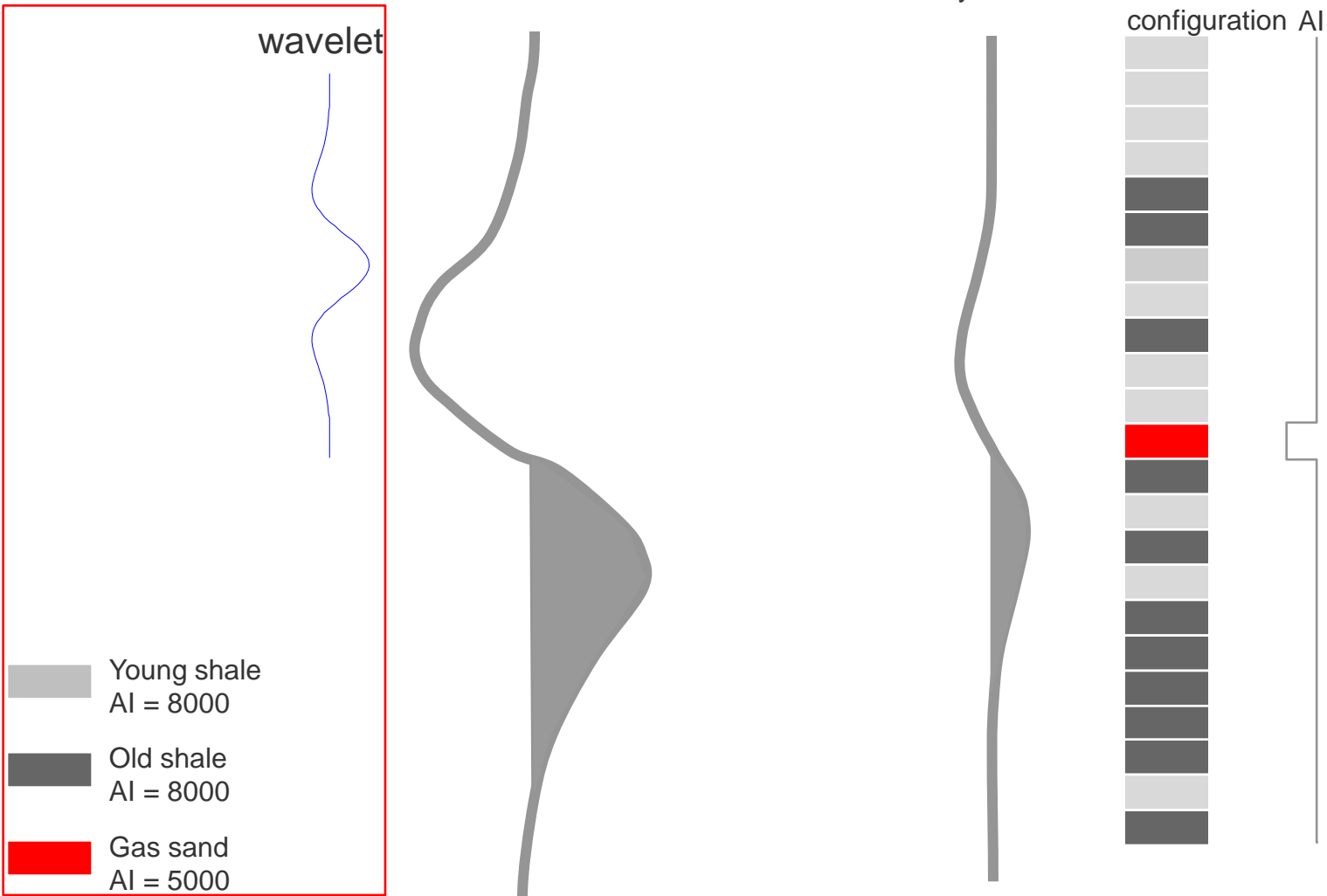
Model 1 – very poor match



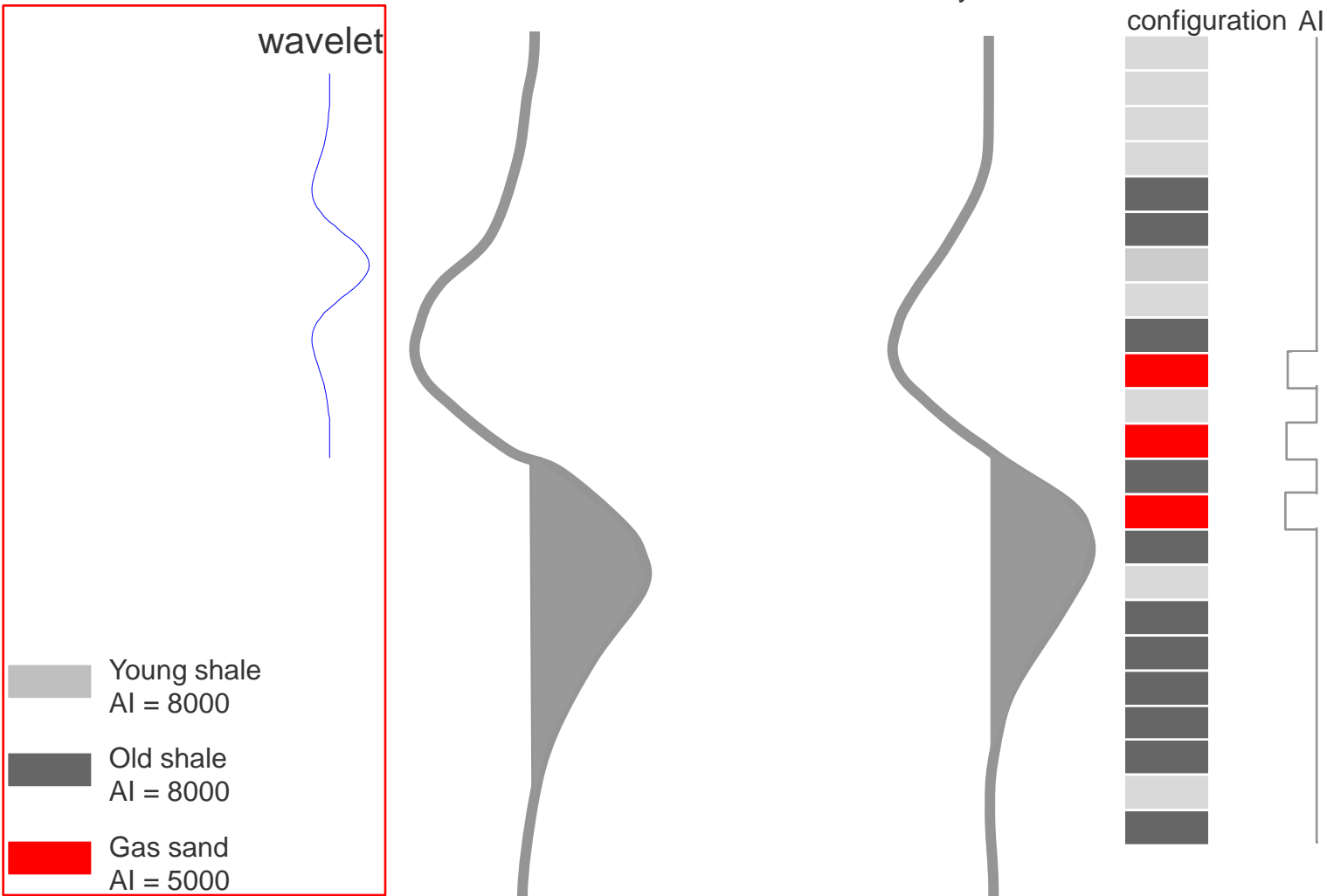
Model 2 – very poor match



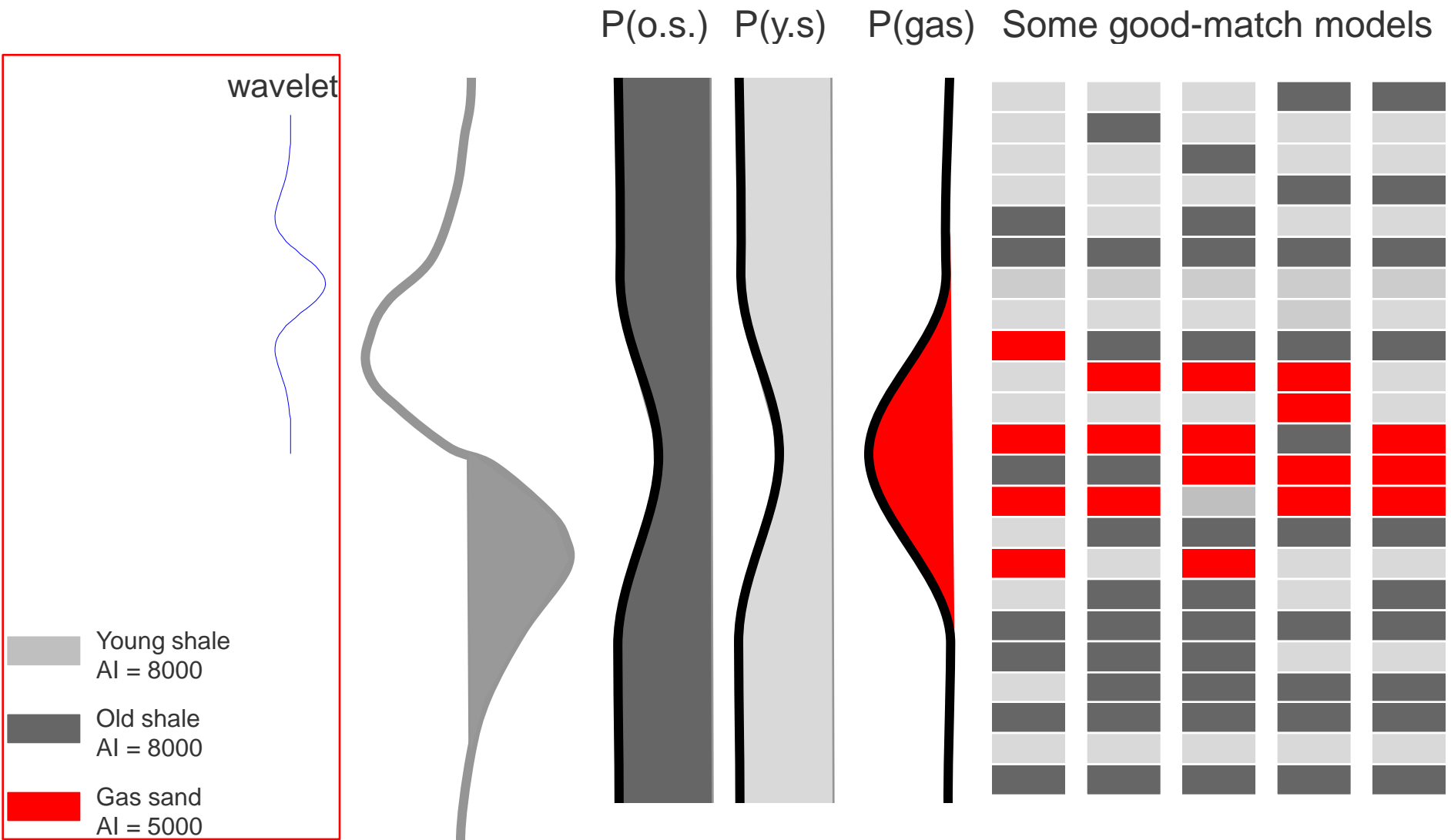
Model 3 poor match



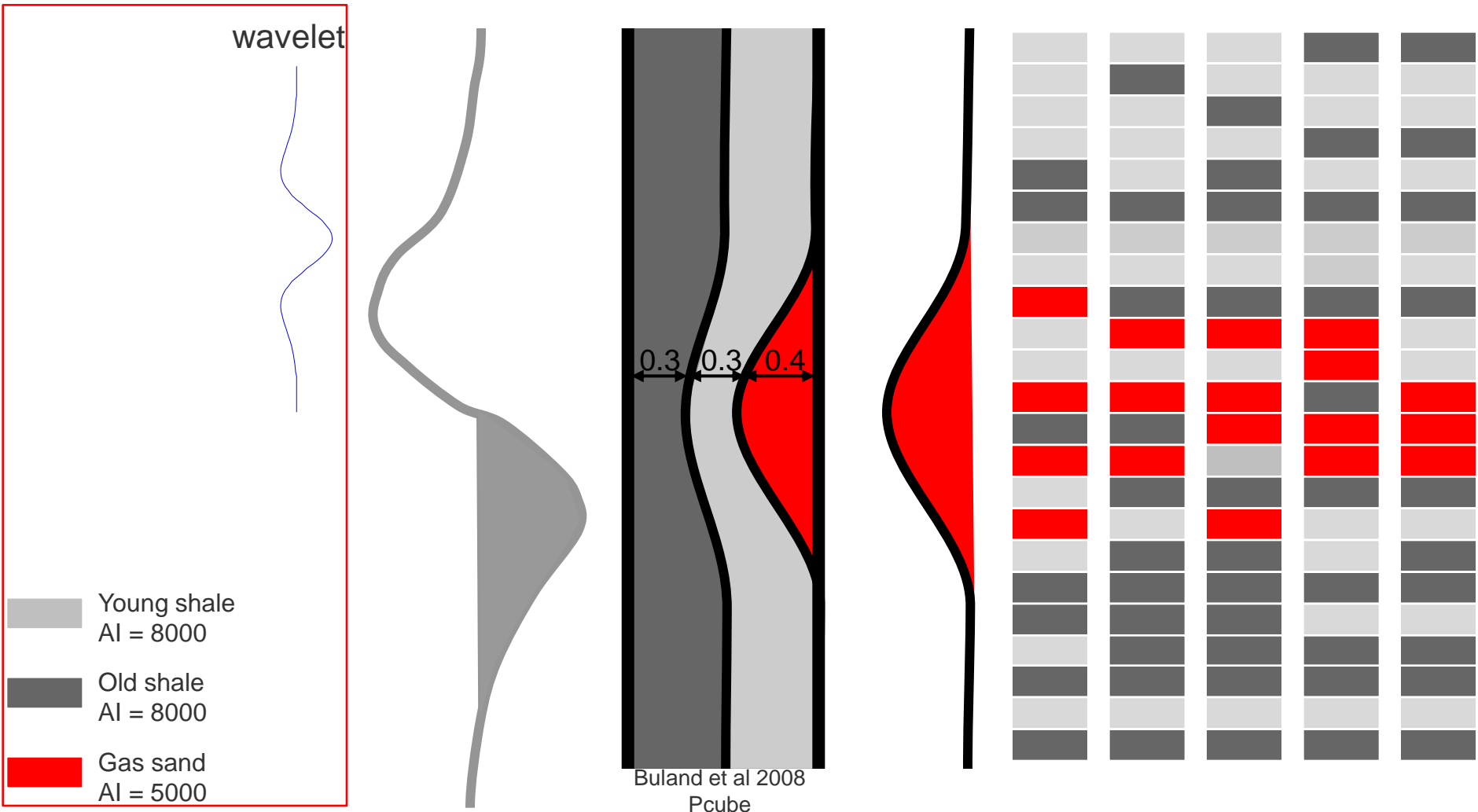
Model 4 good match



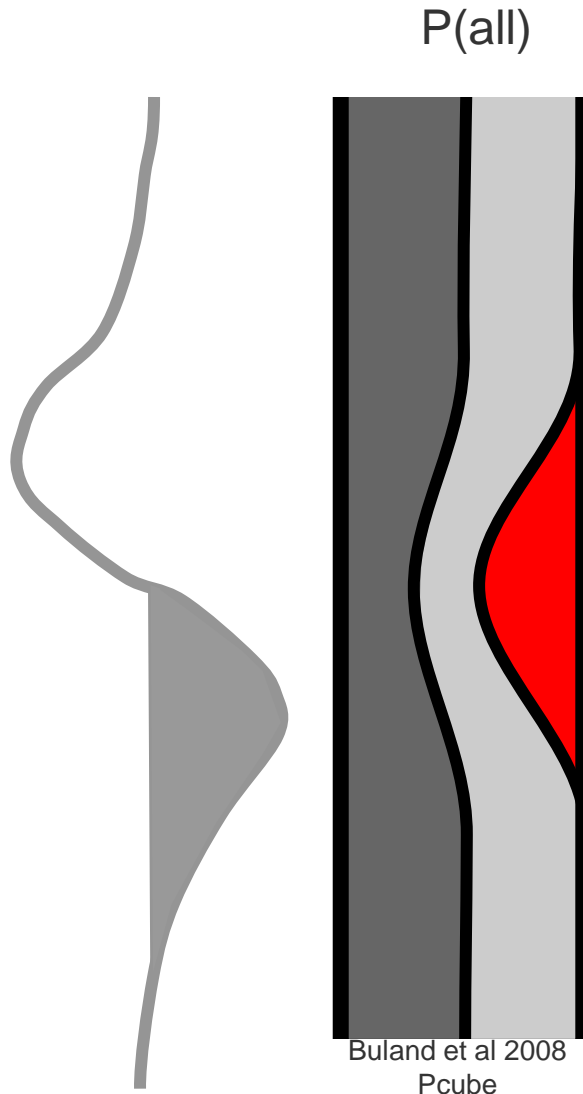
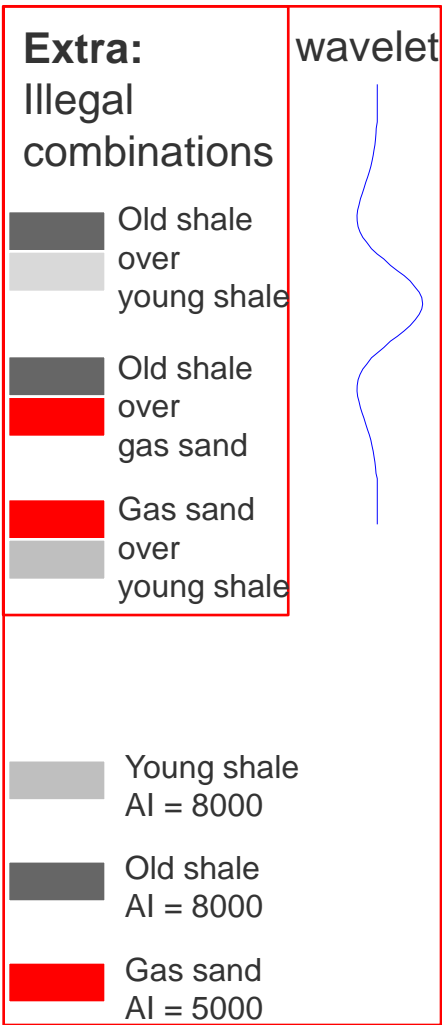
Probability: match-weighted sum of all models



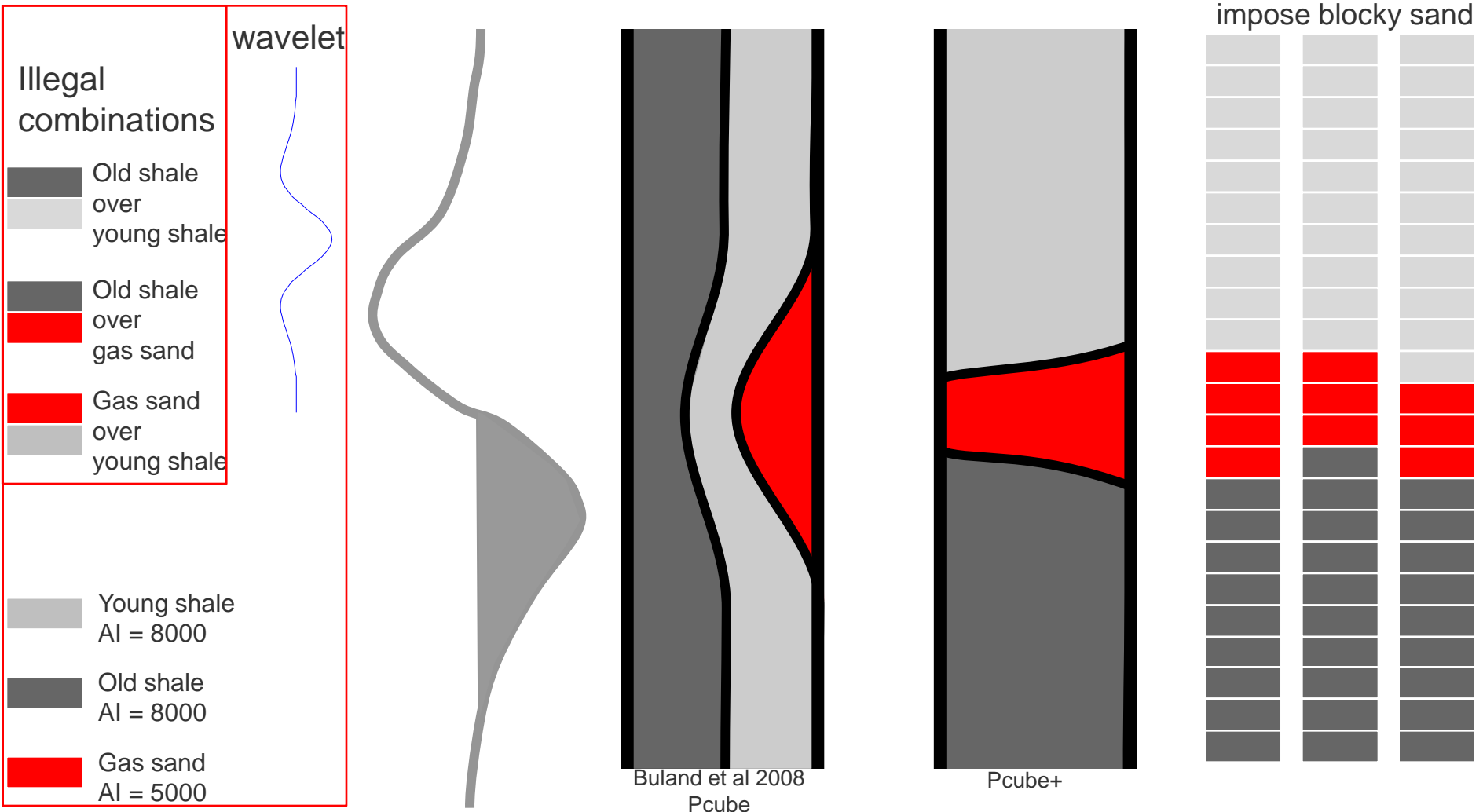
Probability: match-weighted sum of all models



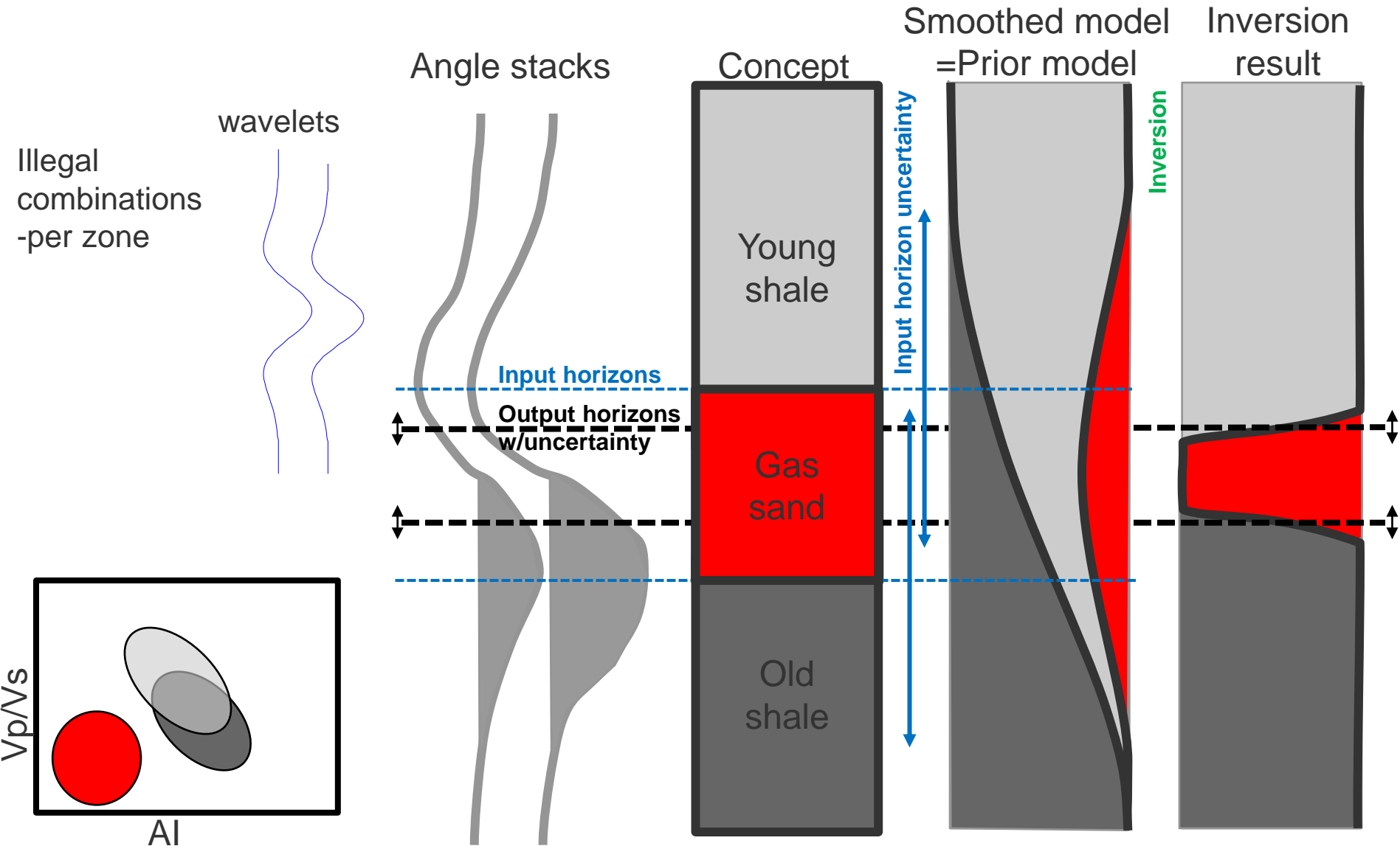
Probability: match-weighted sum of all models



Probability: match-weighted sum of all legal models

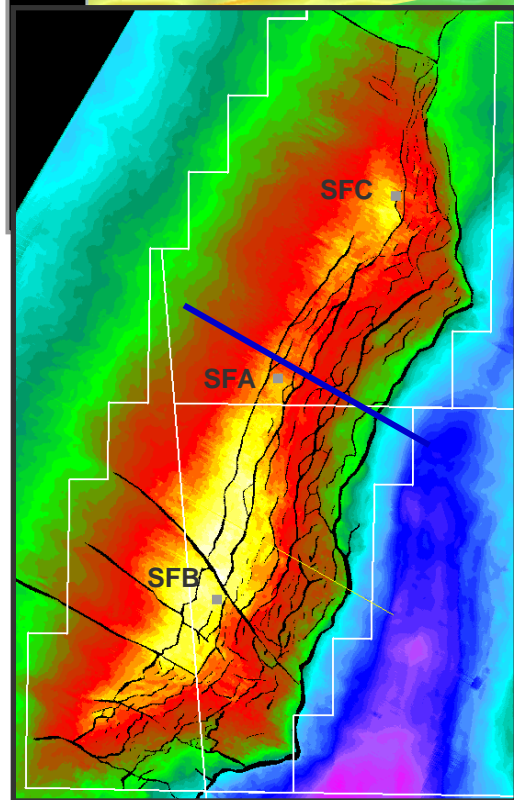
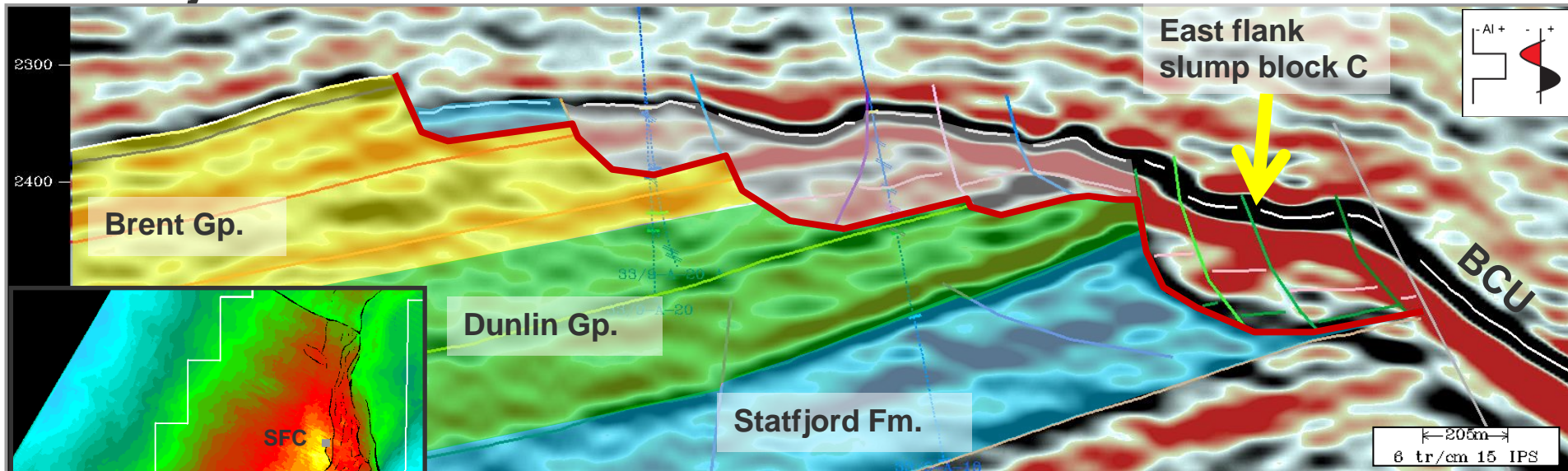


Actual setup – prestack case



Knowledge of properties and assumption of blocky sand enables detailed horizon prediction below tuning thickness

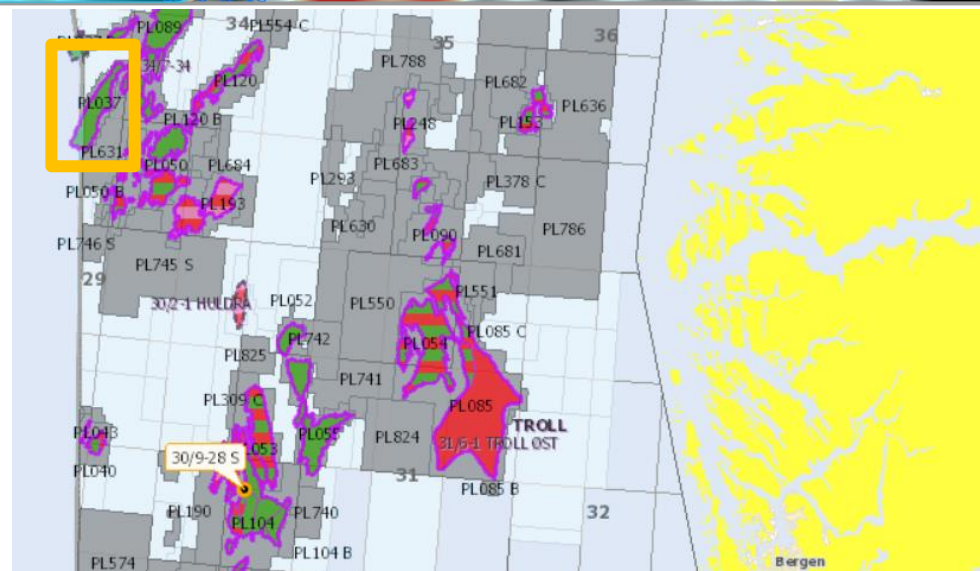
Statfjord East flank



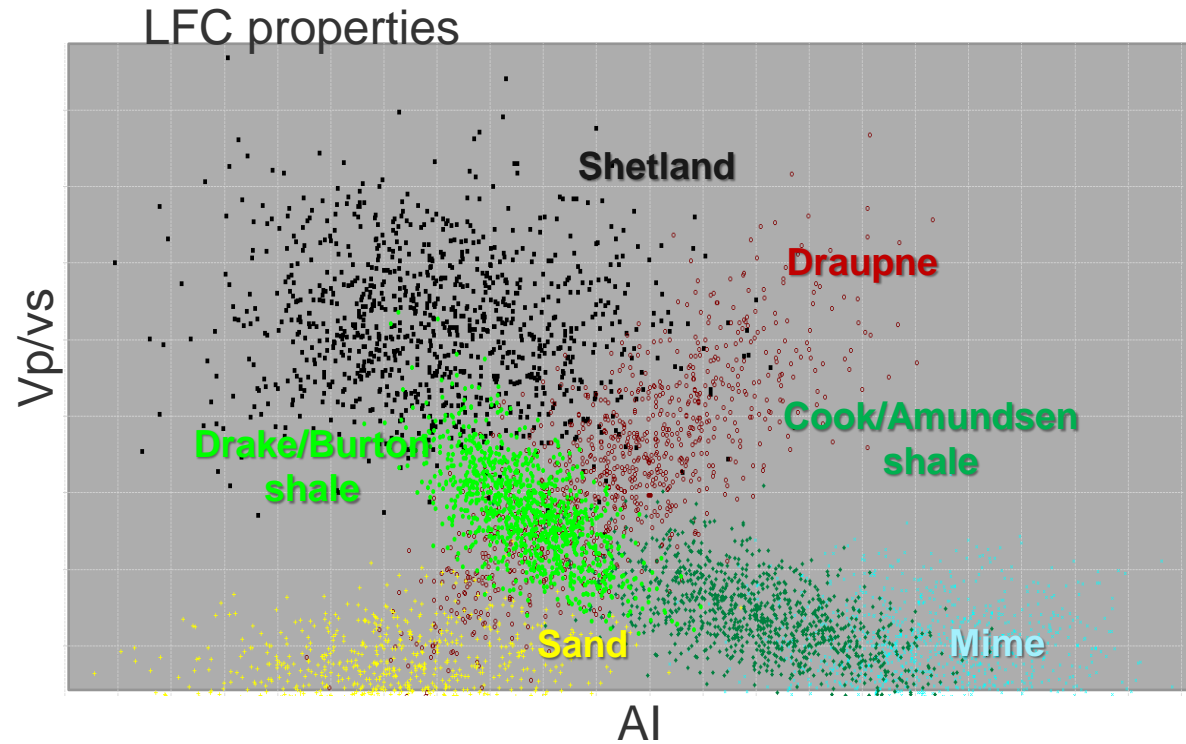
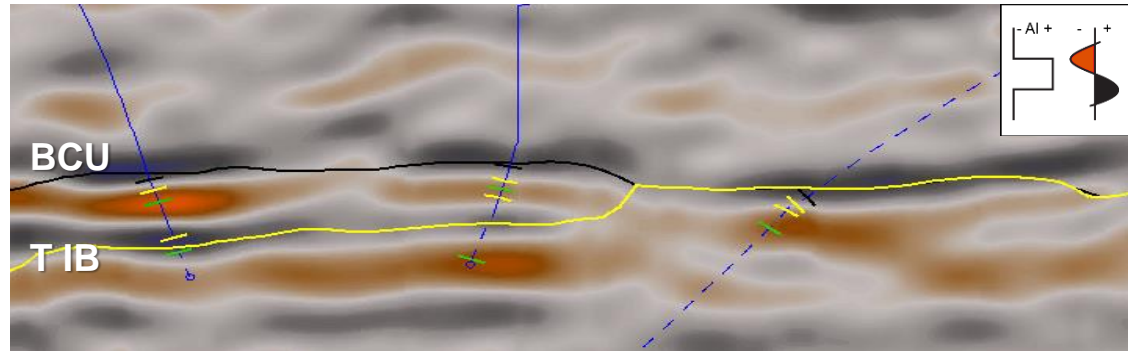
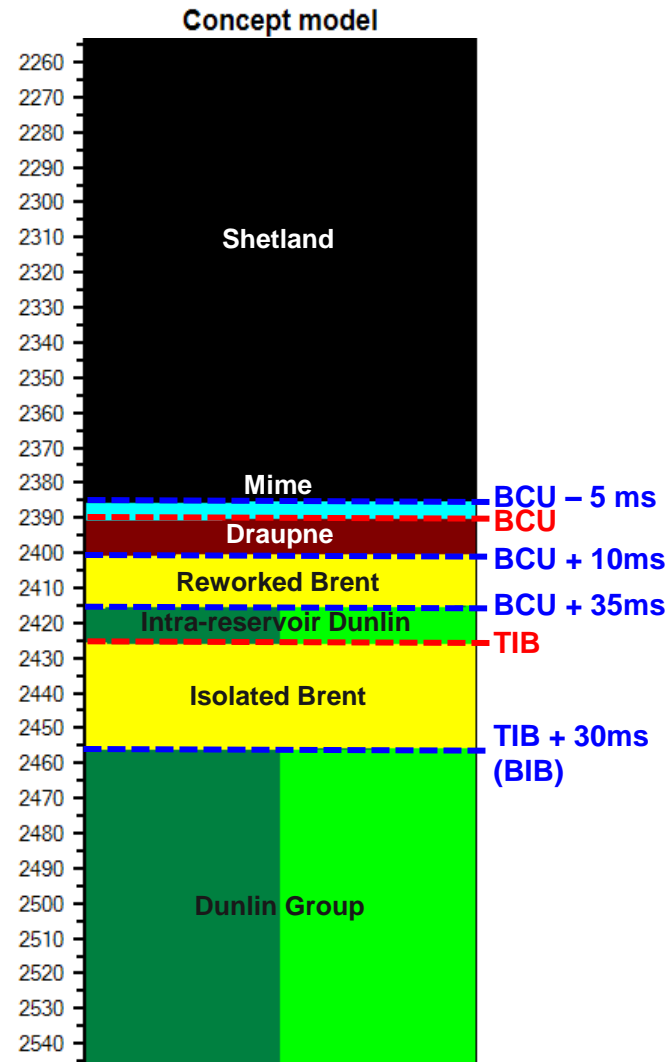
Prod. start
1979

300+ wells

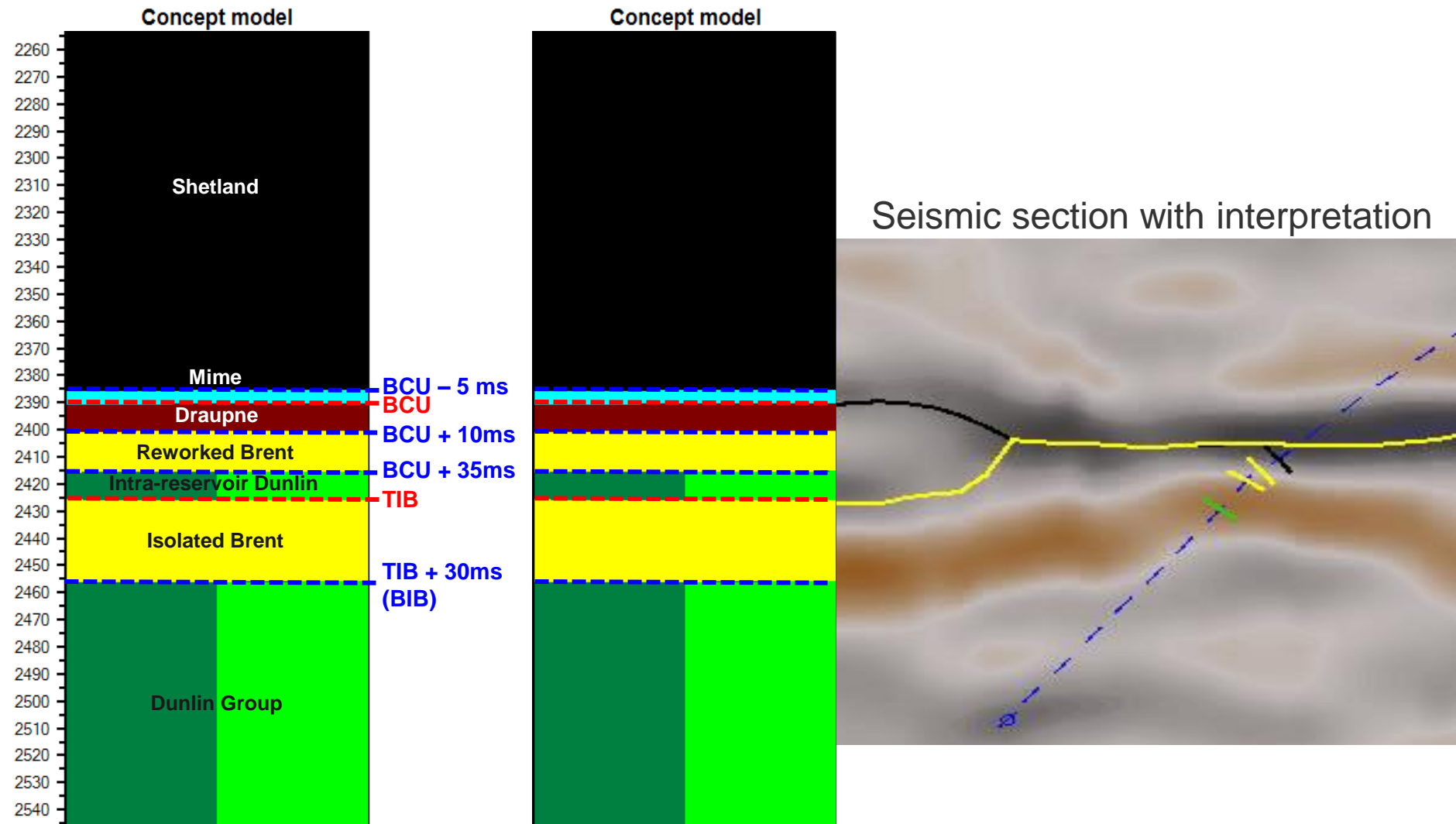
Partners:
Statoil
Centrica
ExxonMobil



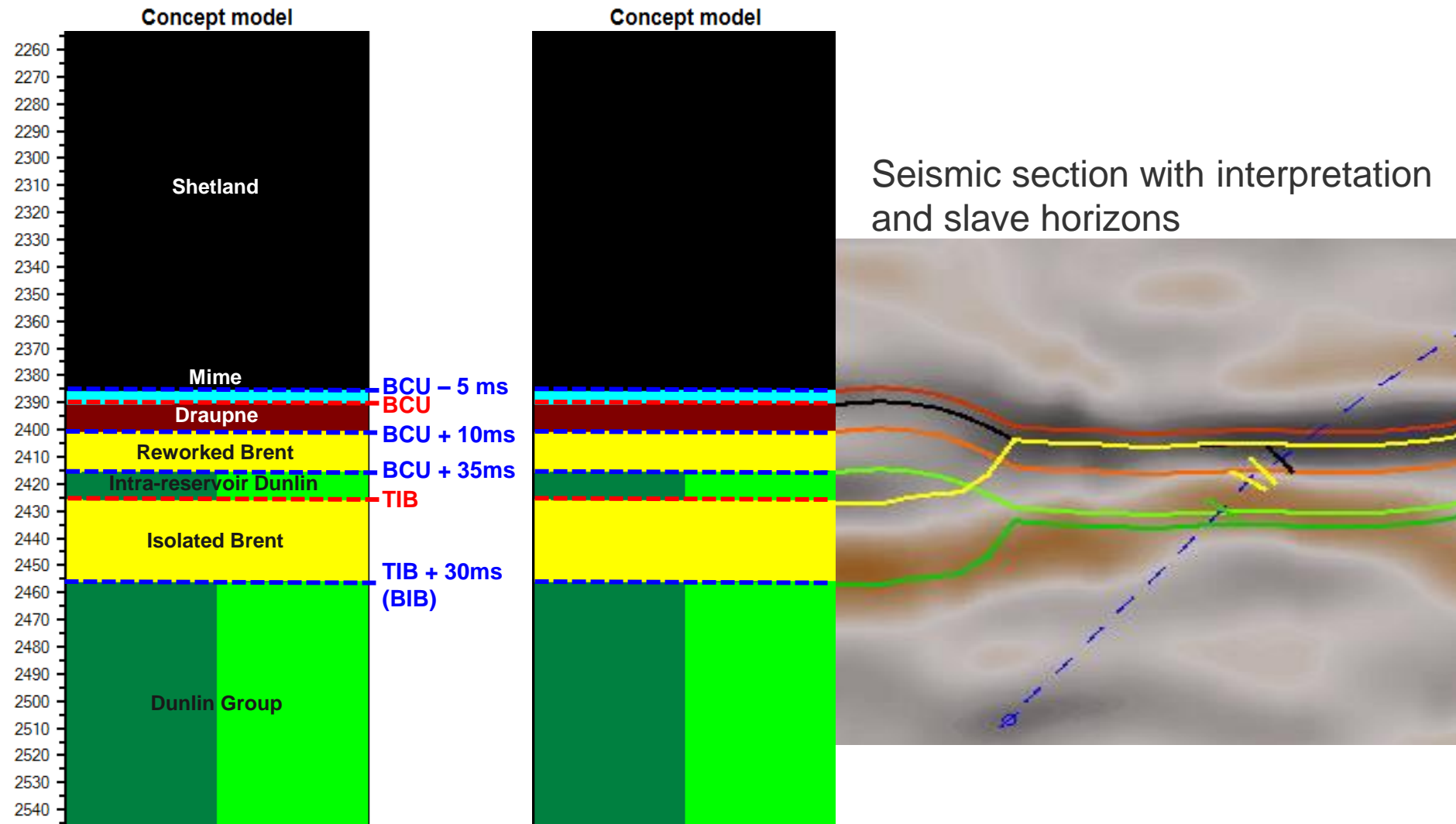
Statfjord – model setup



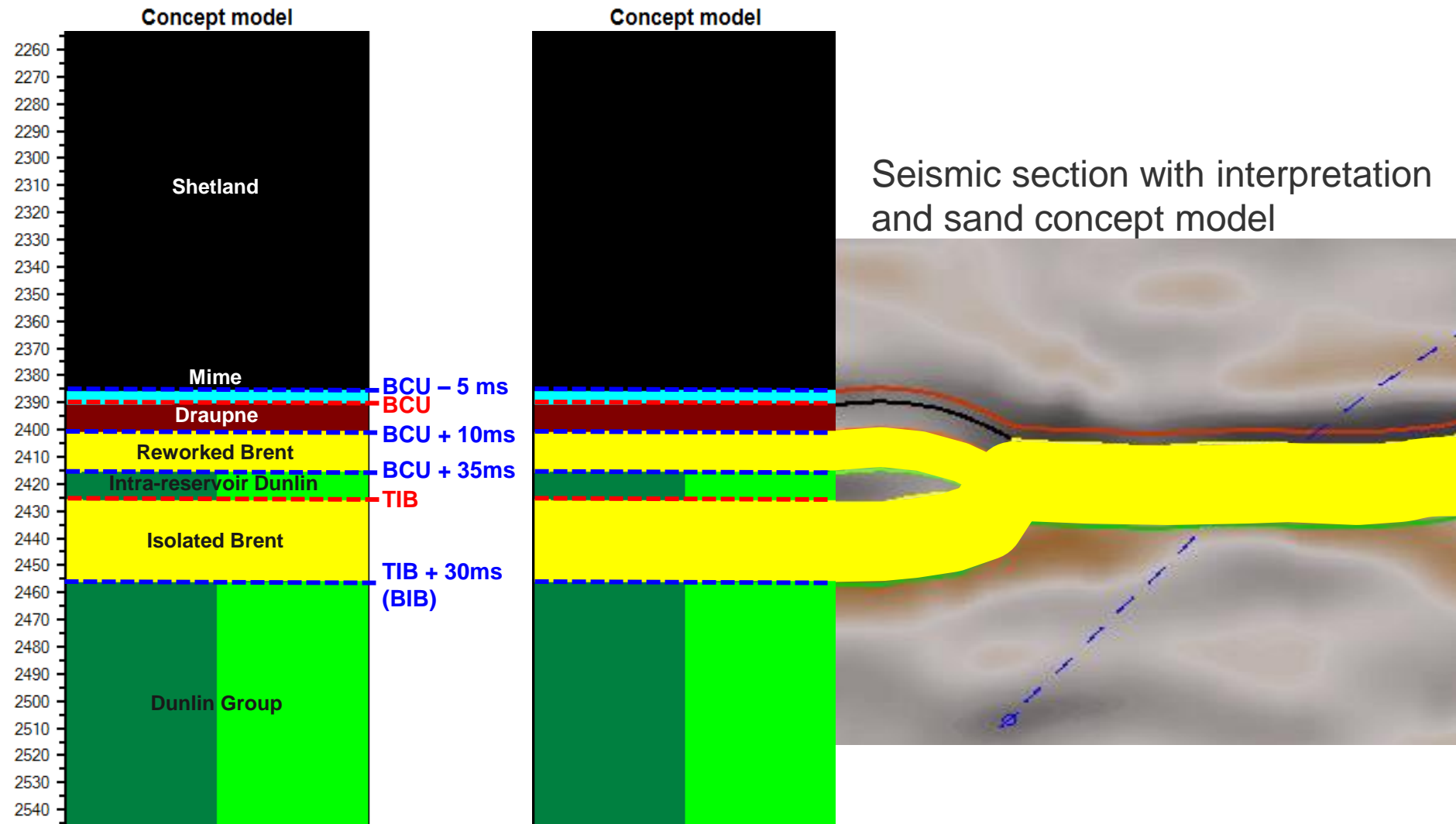
Statfjord – model setup



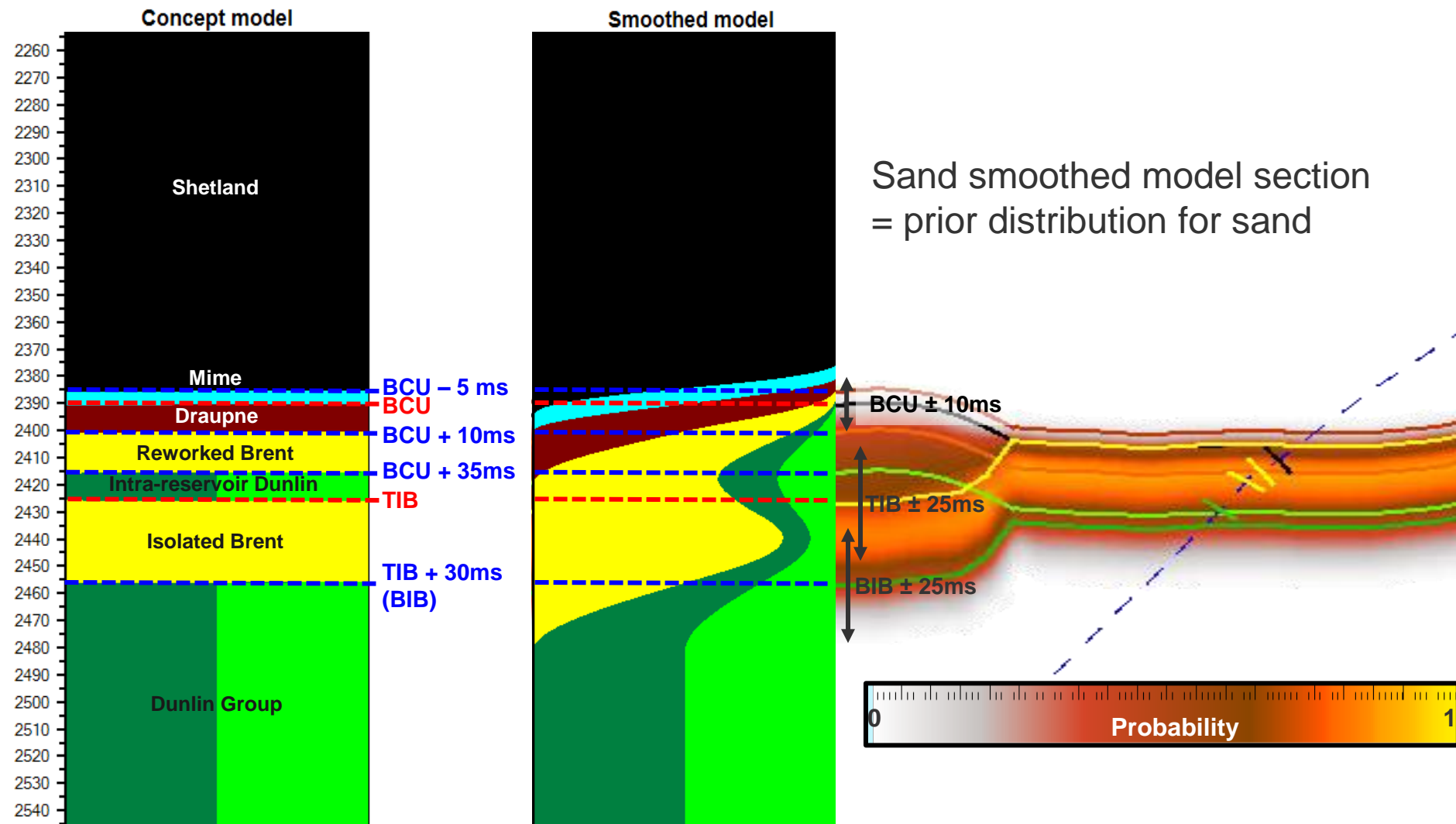
Statfjord – model setup – slave horizons



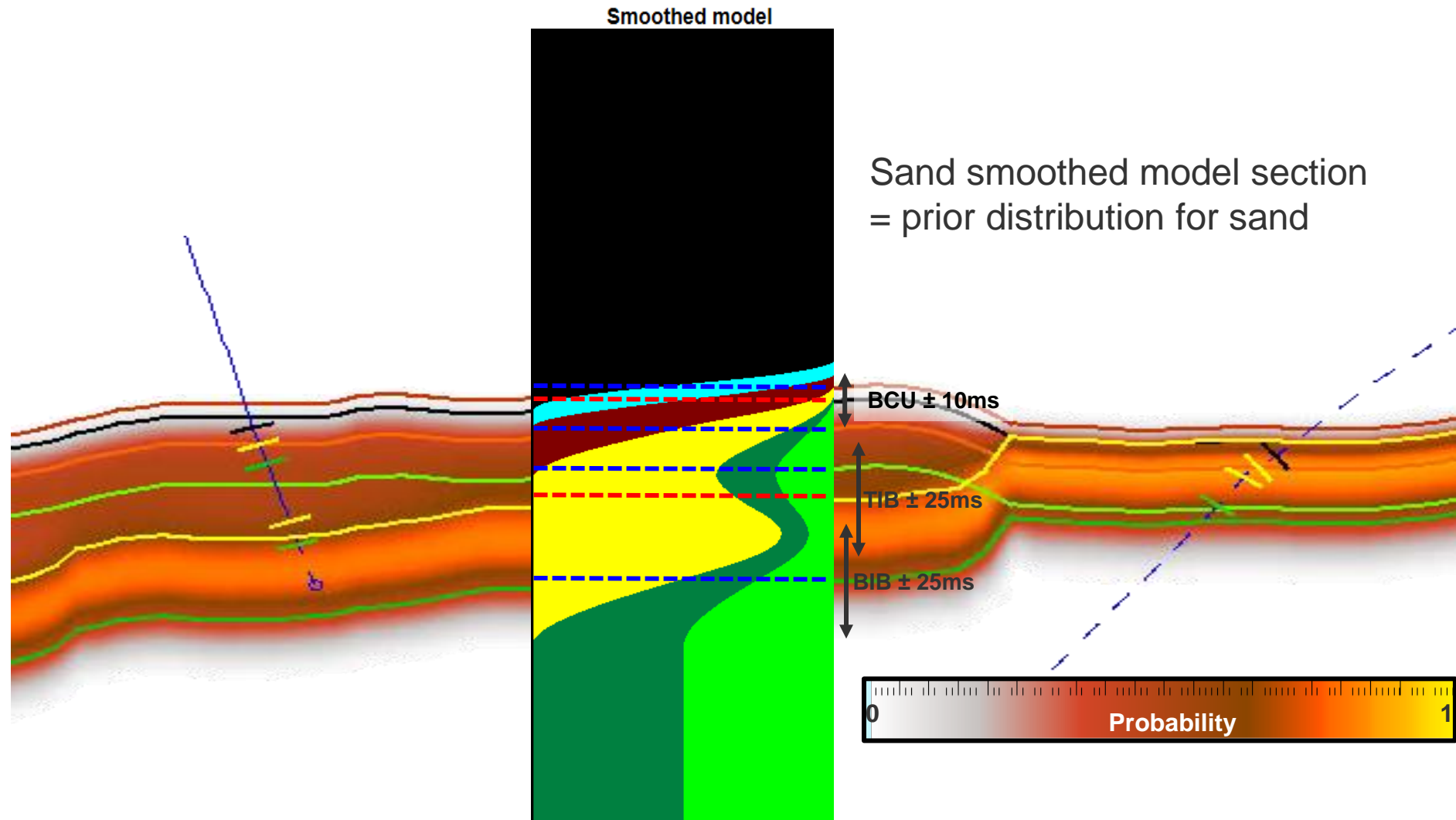
Statfjord – model setup – slave horizons



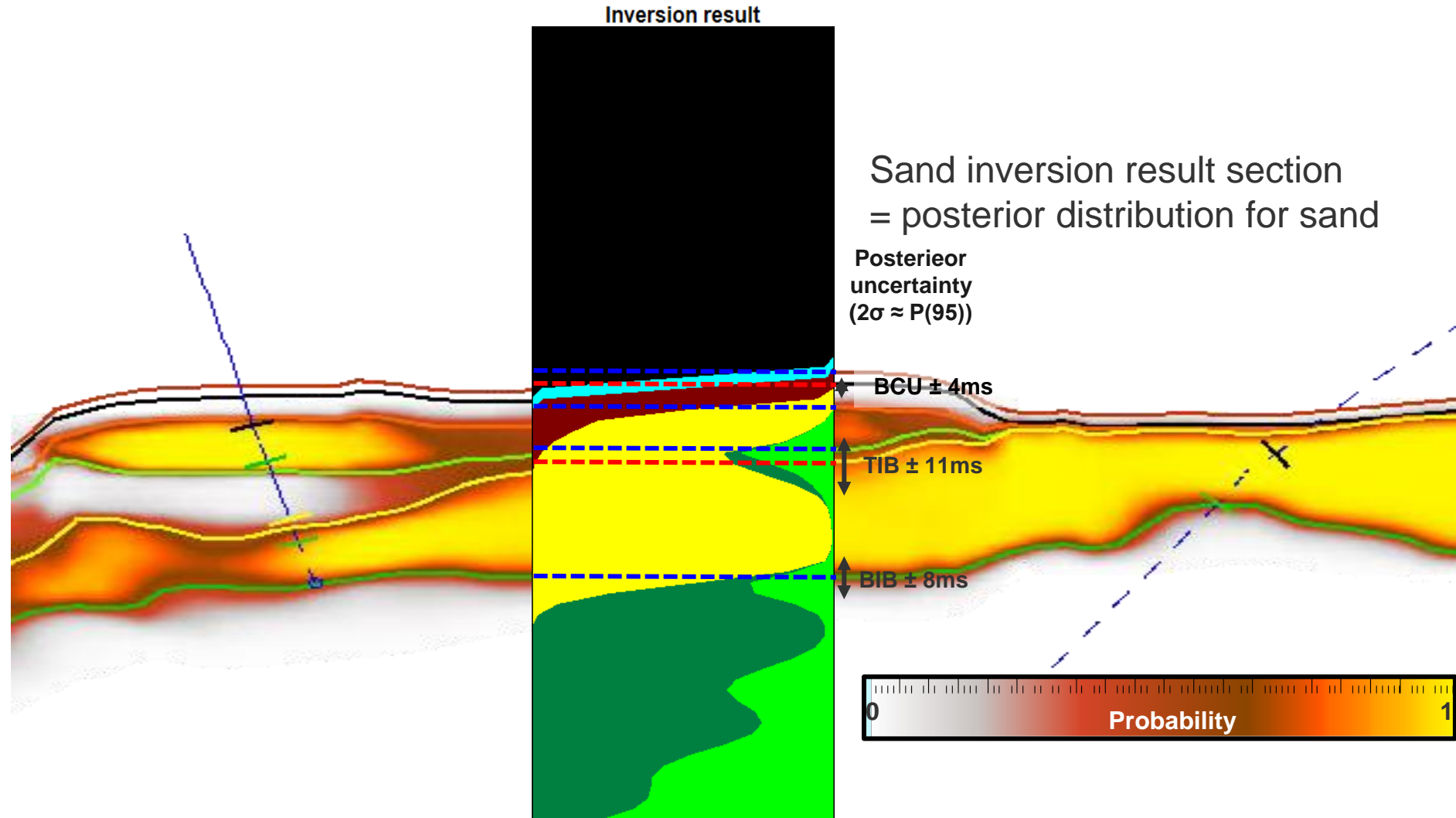
Statfjord – model setup – sand prior section



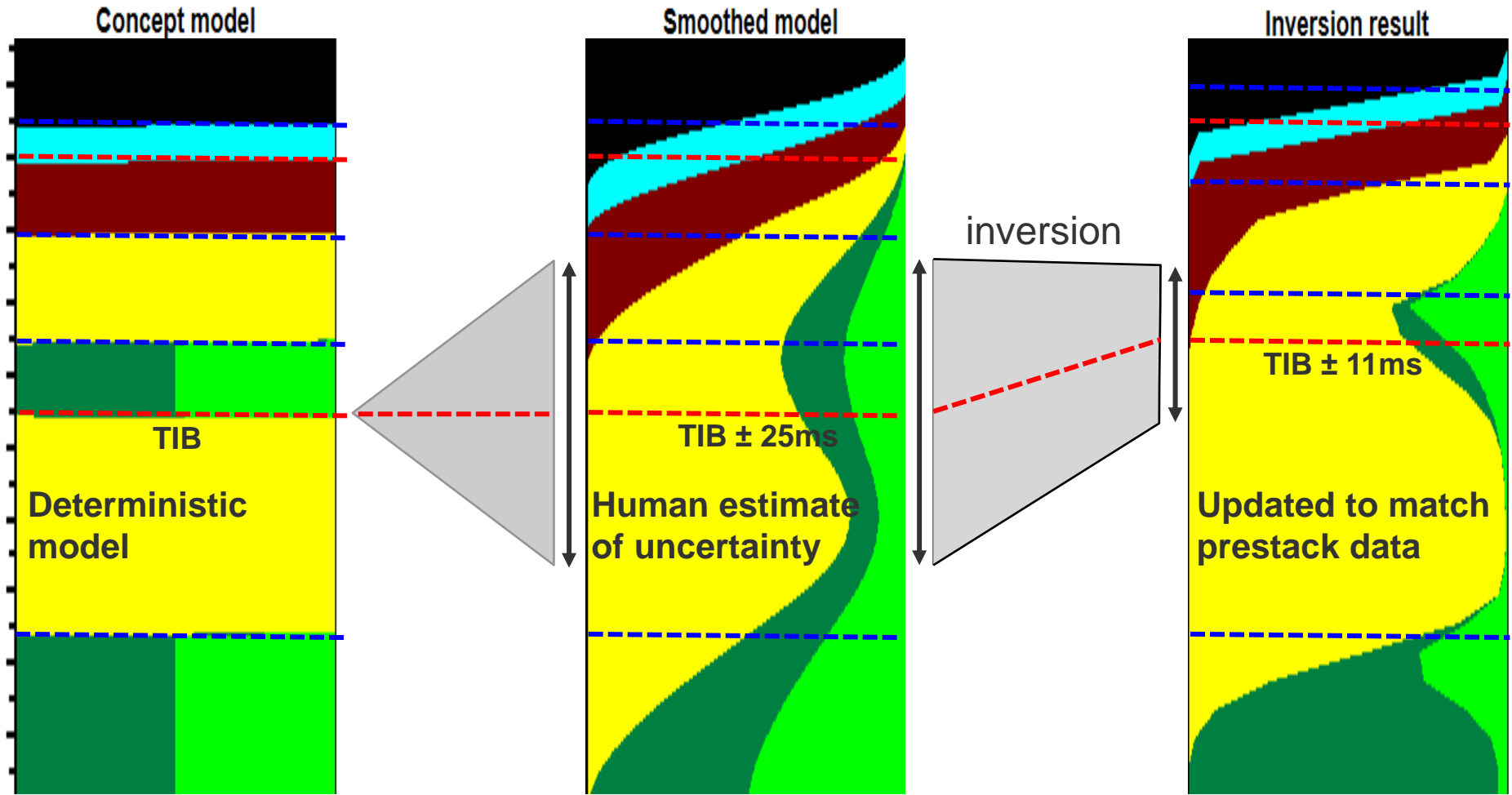
Statfjord – model setup – sand prior section



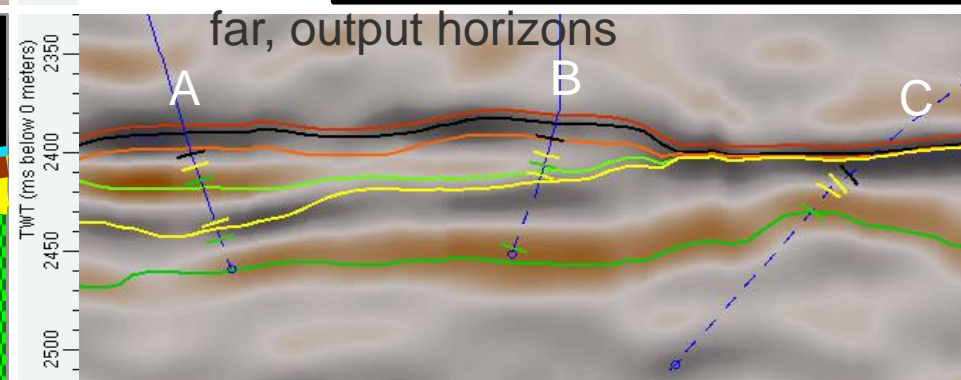
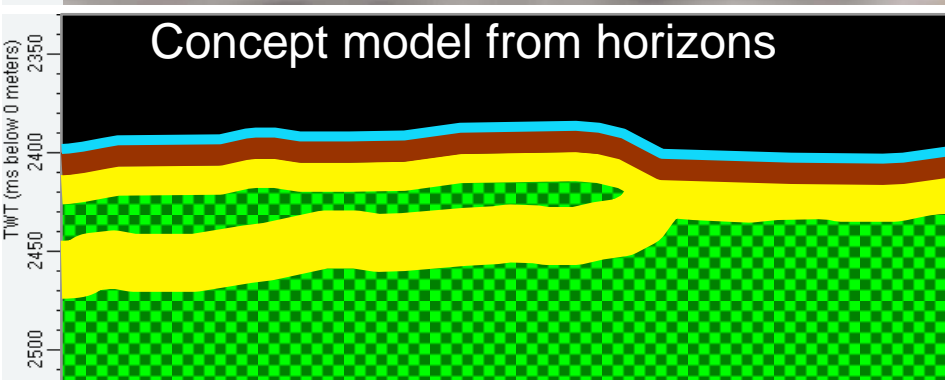
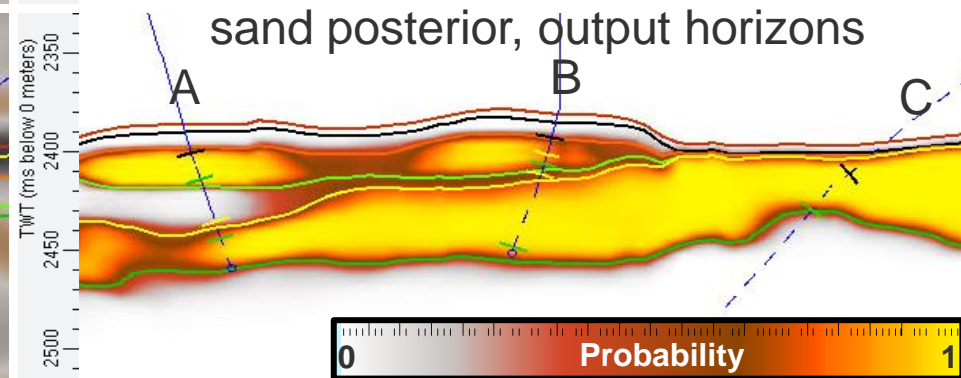
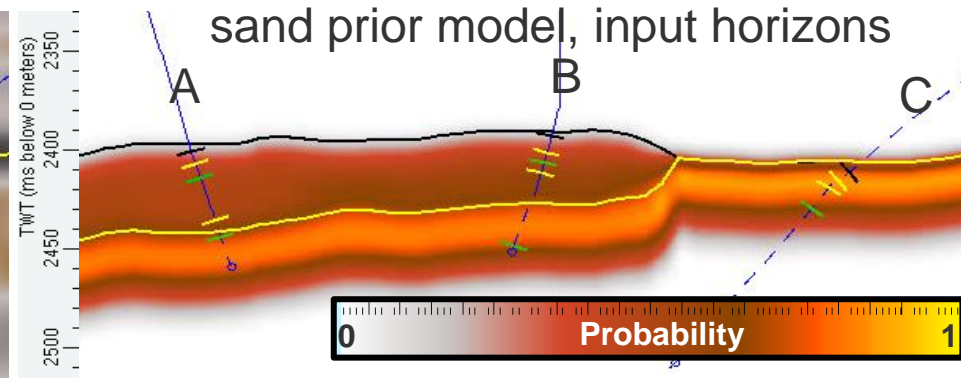
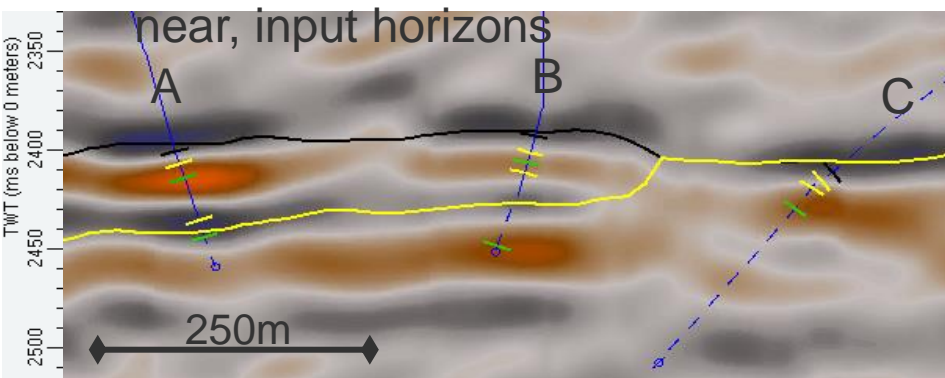
Statfjord – model setup – sand post. section



Inversion process – one trace

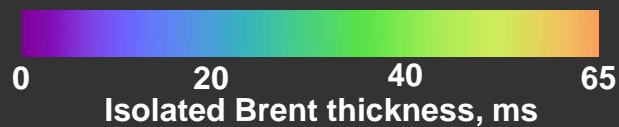
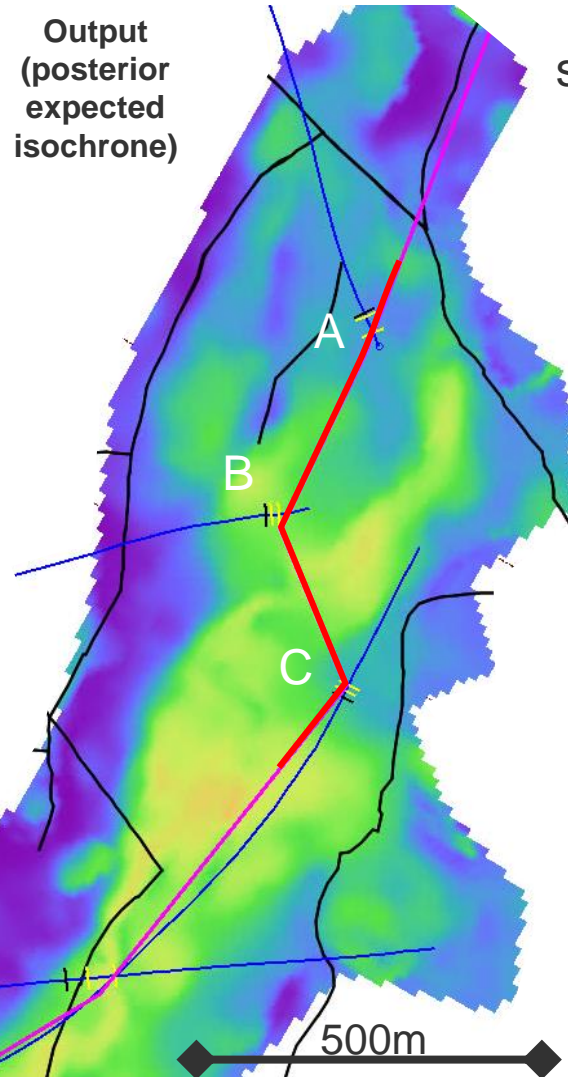
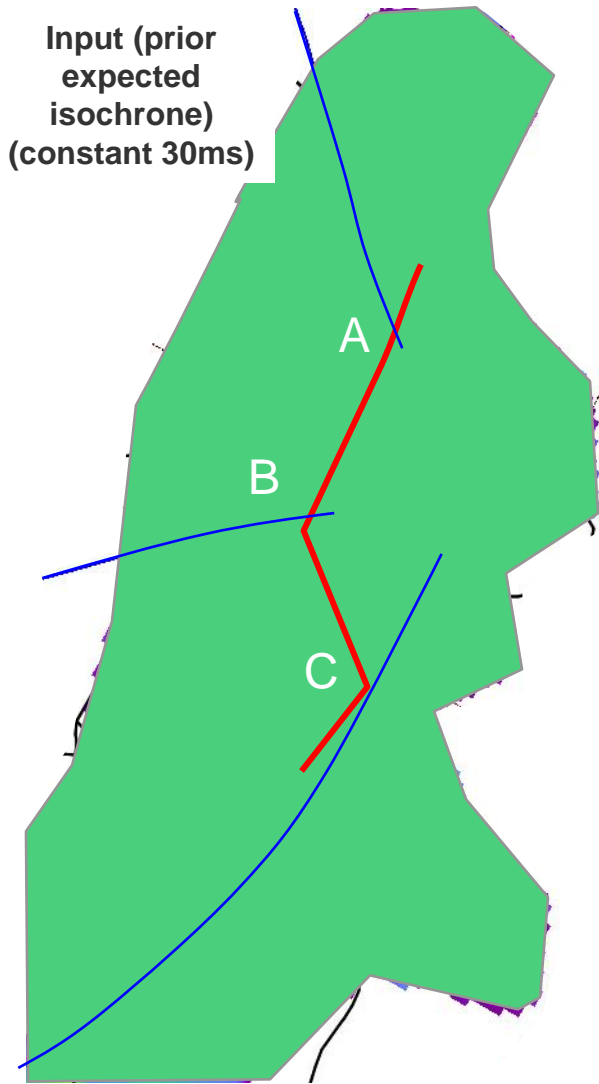


Input data, sand probability and horizons

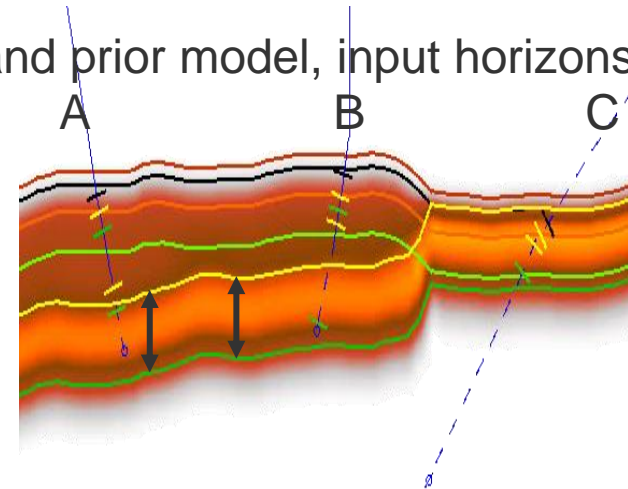


Mid stack also used as input but not shown

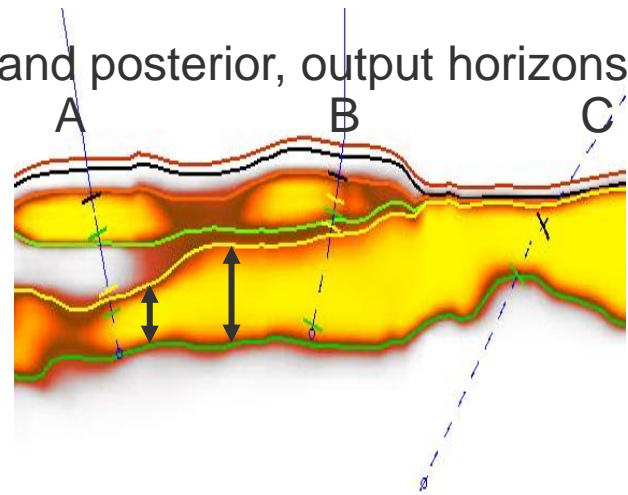
Isochrone Isolated Brent sand



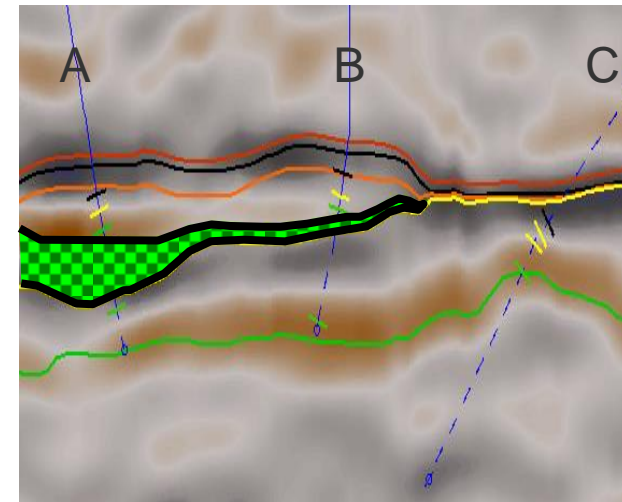
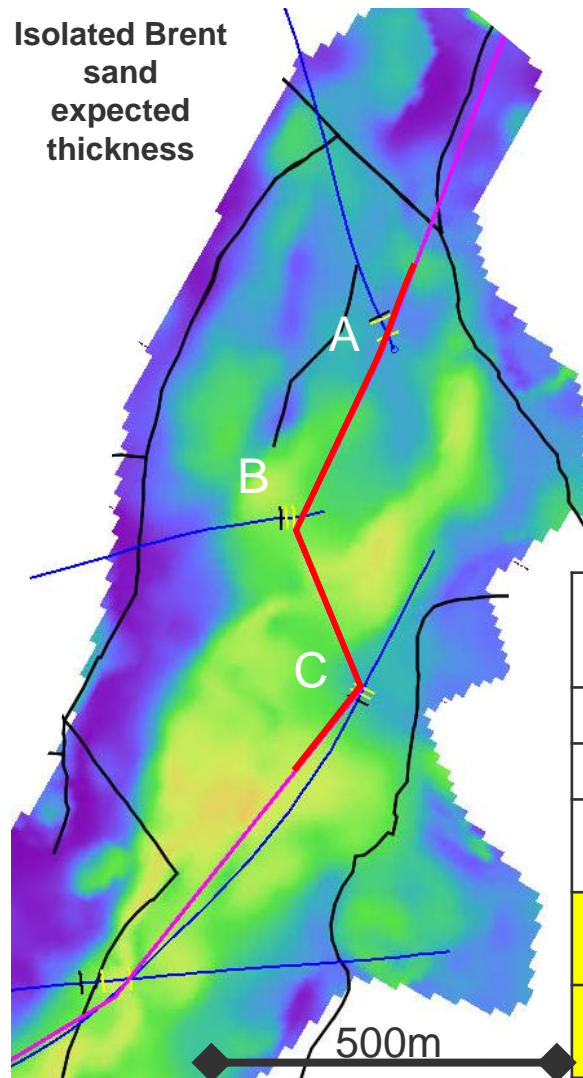
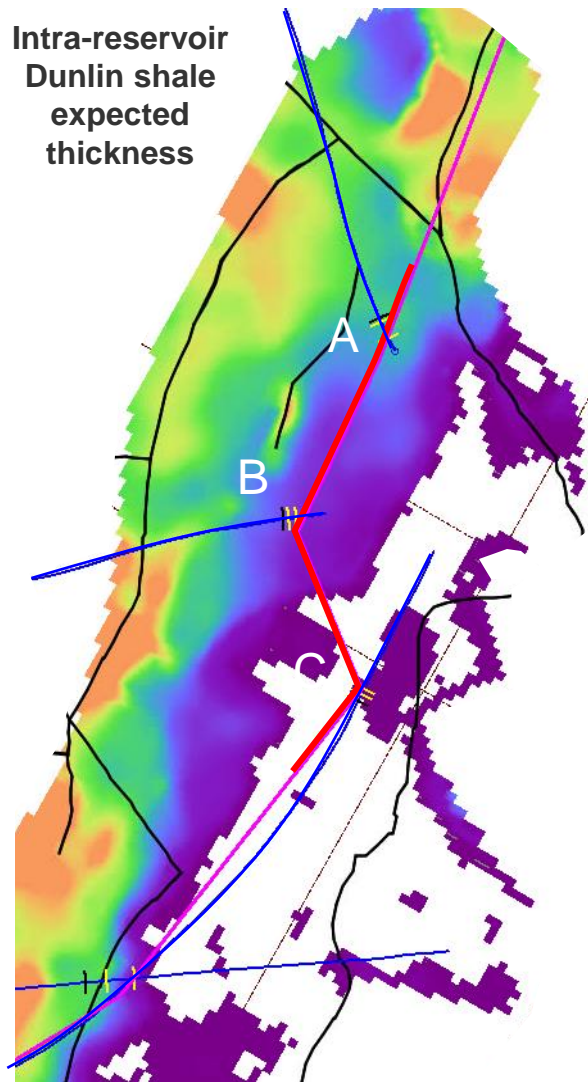
sand prior model, input horizons



sand posterior, output horizons



Isochrone prediction vs well result



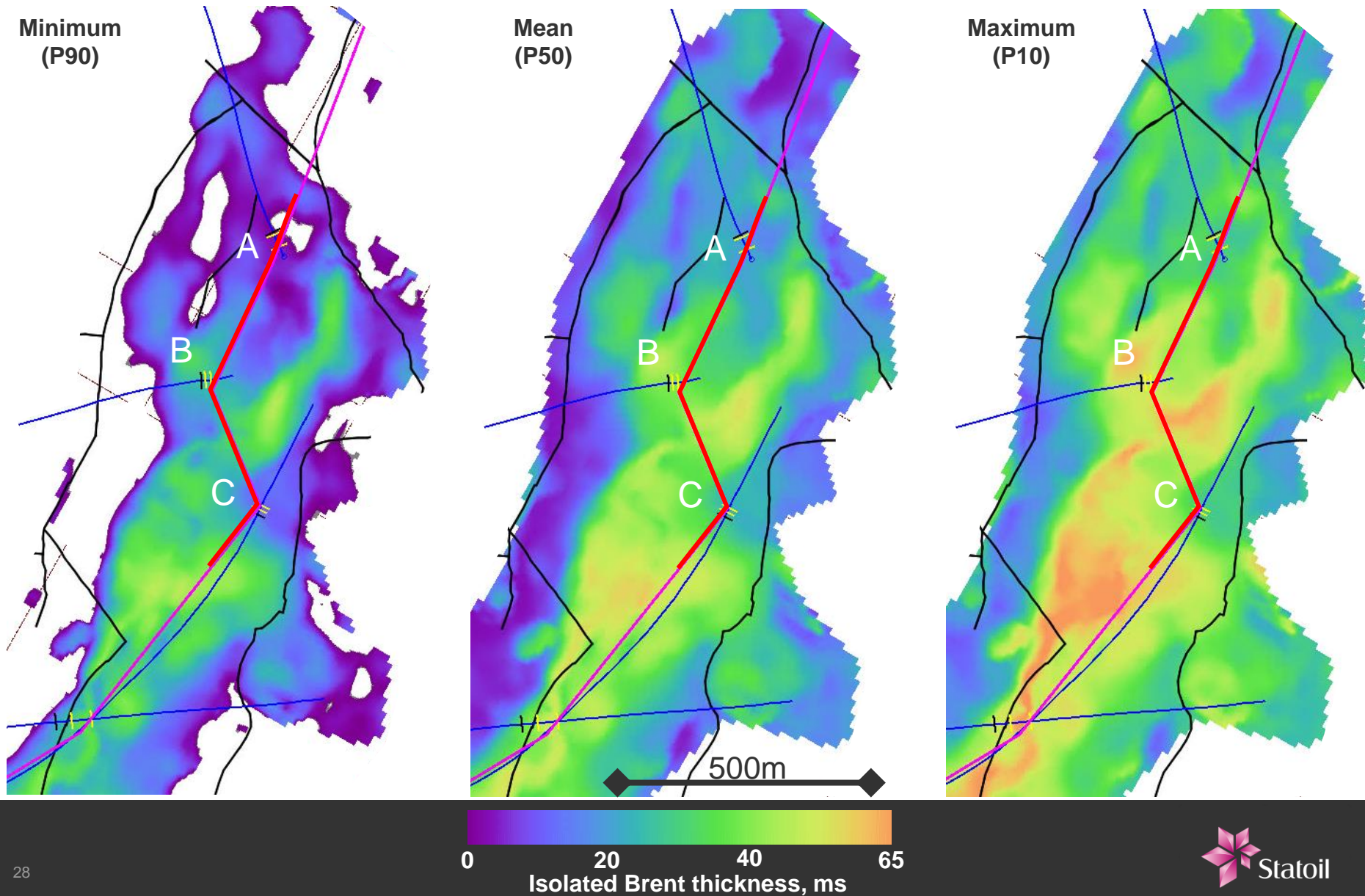
Well B result (Jan 2016)

Formation	TVT est. pre-inv (m)	TVT est. post-inv(m)	TVT well obs. (m)
Mime	3	4	4
Draupne	9	10	12
Reworked Brent	20	18	8
Intra-res Dunlin	17	7	7
Isolated Brent	36	58	55

0 10 20 30 40 50
Intra-Reservoir Dunlin thickness, ms

0 20 40 65
Isolated Brent thickness, ms

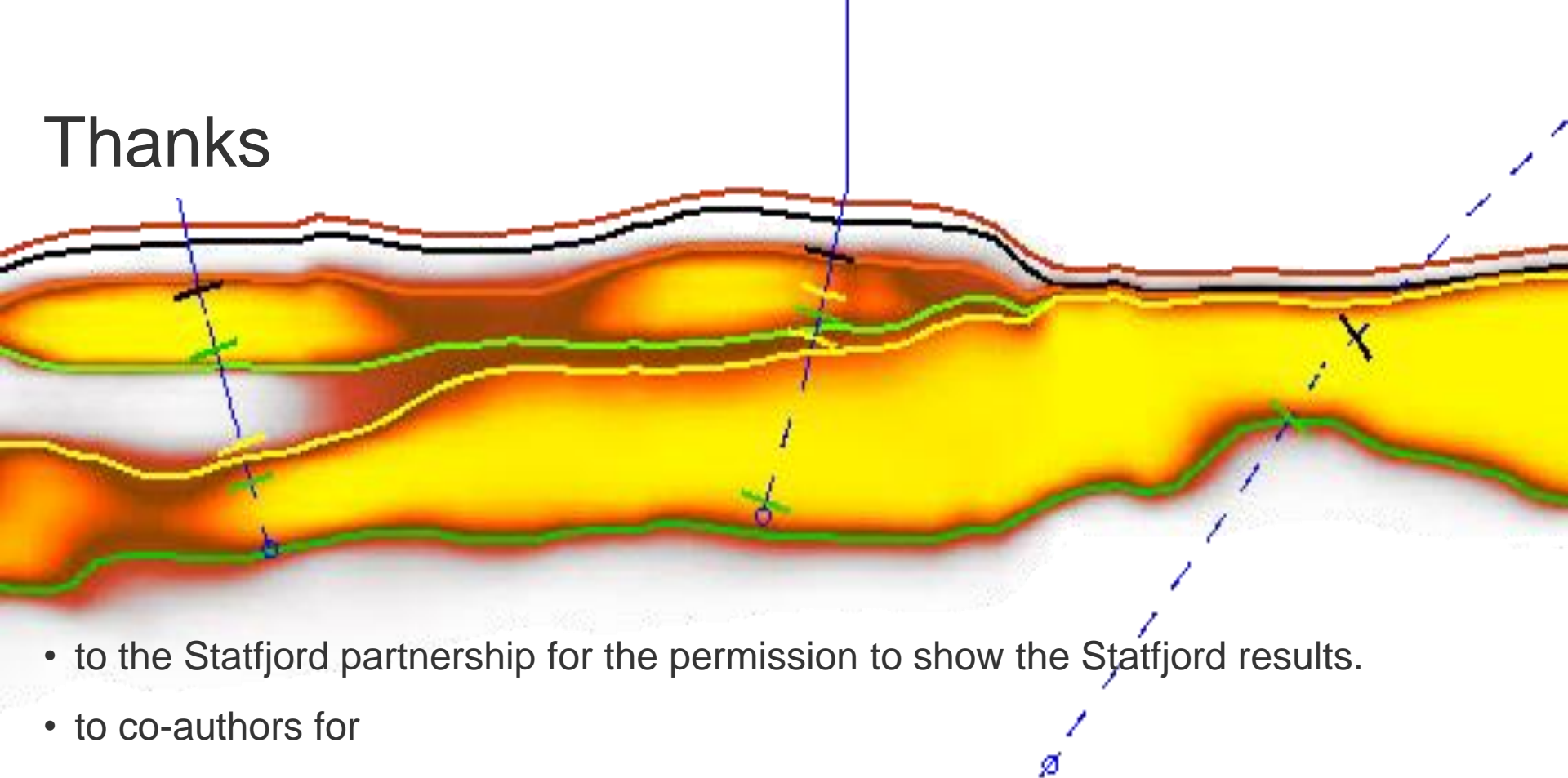
Isochrone Isolated Brent sand - uncertainty



Concluding remarks

- Working with sand probability and uncertain horizons as input and output:
 - Facilitates integration of geoscience.
 - Easy to relate to for all disciplines compared to AI and vp/vs input/output
- Accurate horizon placement - below tuning, away from peak and trough is valuable
 - Horizons with uncertainty are often what we want
 - Volumetrics, well planning, geomodels, instant isochrones
- Constraining the inversion is key to achieving sub-tuning detail
 - Limited number of lithologies – limited combinations of vp,vs,p allowed
 - Limiting where the lithologies can be – based on geological input
 - Excluding non-geological and non-physical layering (e.g. brine just above gas)
- Making amplitudes move horizons is making amplitudes matter.

Thanks



- to the Statfjord partnership for the permission to show the Statfjord results.
- to co-authors for
 - doing the Statfjord work (Richard)
 - developing the technique and setting up a JIP to take it further (NR)
- to you for listening