



Geometrical stacking for fluid contact analysis

Examples from the North Sea Dutch sector

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Outline

- Introduction
- Base Vlieland Shale example
- Top Middle Bunter example
- Top Rotliegend example
- Conclusions





Outline

➤ Introduction

➤ Base Vlieland Shale example

➤ Top Middle Bunter example

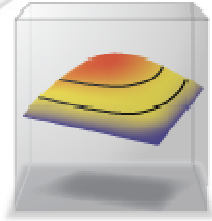
➤ Top Rotliegend example

➤ Conclusions





Common Contour Binning



Objective:

- Detect subtle hydro-carbon related anomalies and pin-point contacts (GWC, GOC and OWC)

Principle:

- Seismic traces that penetrate the top reservoir at the same depth (i.e. lie on the same contour line) have identical hydro-carbon columns.
- Stacking traces along the same contour line thus enhances possible hydrocarbon effects while stratigraphic variations and noise are cancelled.

CCB Outputs:

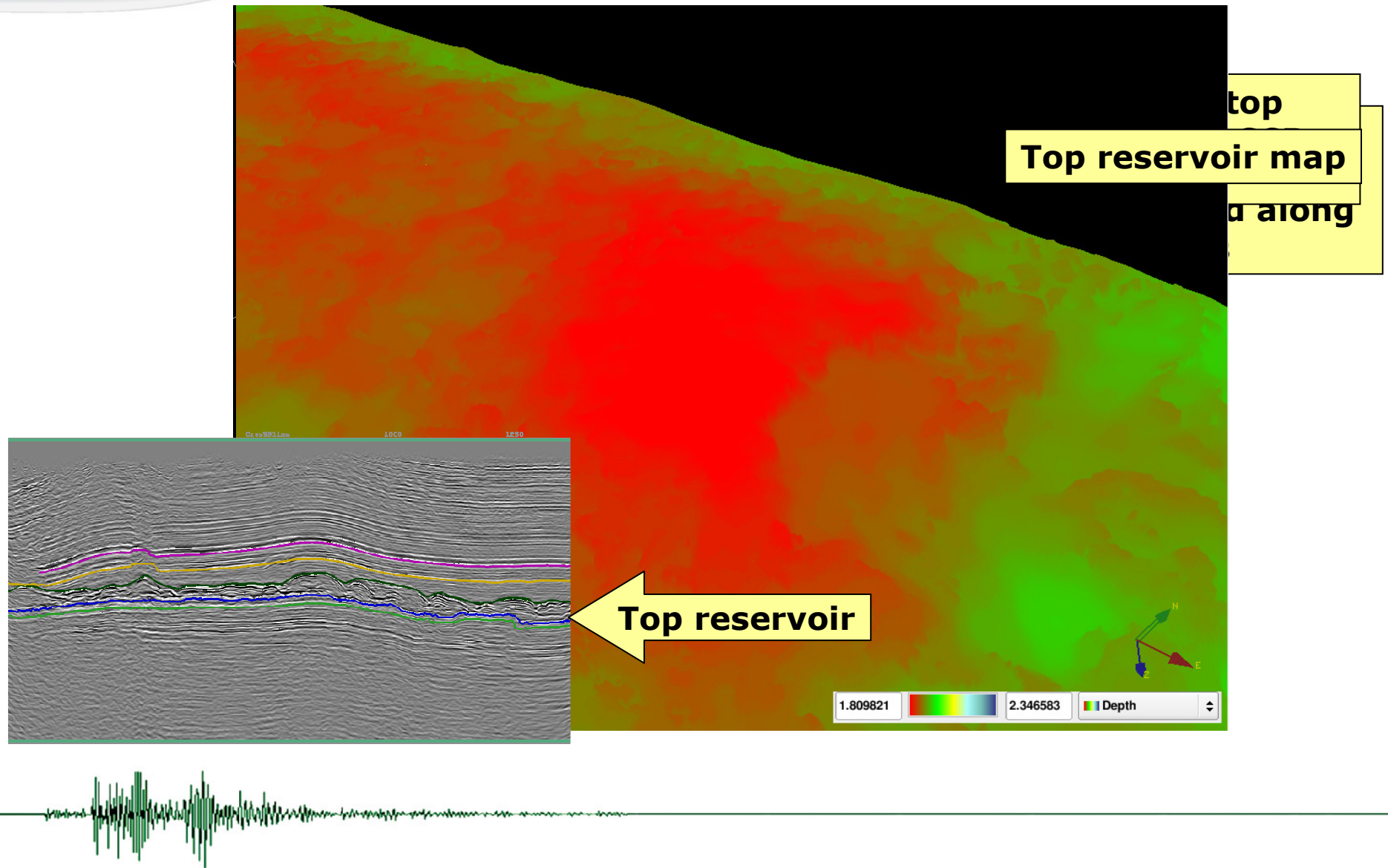
- New 3D volume with stacked traces along contour lines
- CCB stack = 2D section with stacked traces
- Crossplot of stacked amplitudes vs. bin depth

Developed by and for





CCB plugin principle





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Example 1: Base Vlieland Shale

- In this first example Common contour binning was applied around the Base Cretaceous Unconformity (Base Vlieland Shale) at a known prospect.
- The formation below this unconformity is a good reservoir containing gas, while the formation above is a regional seal.



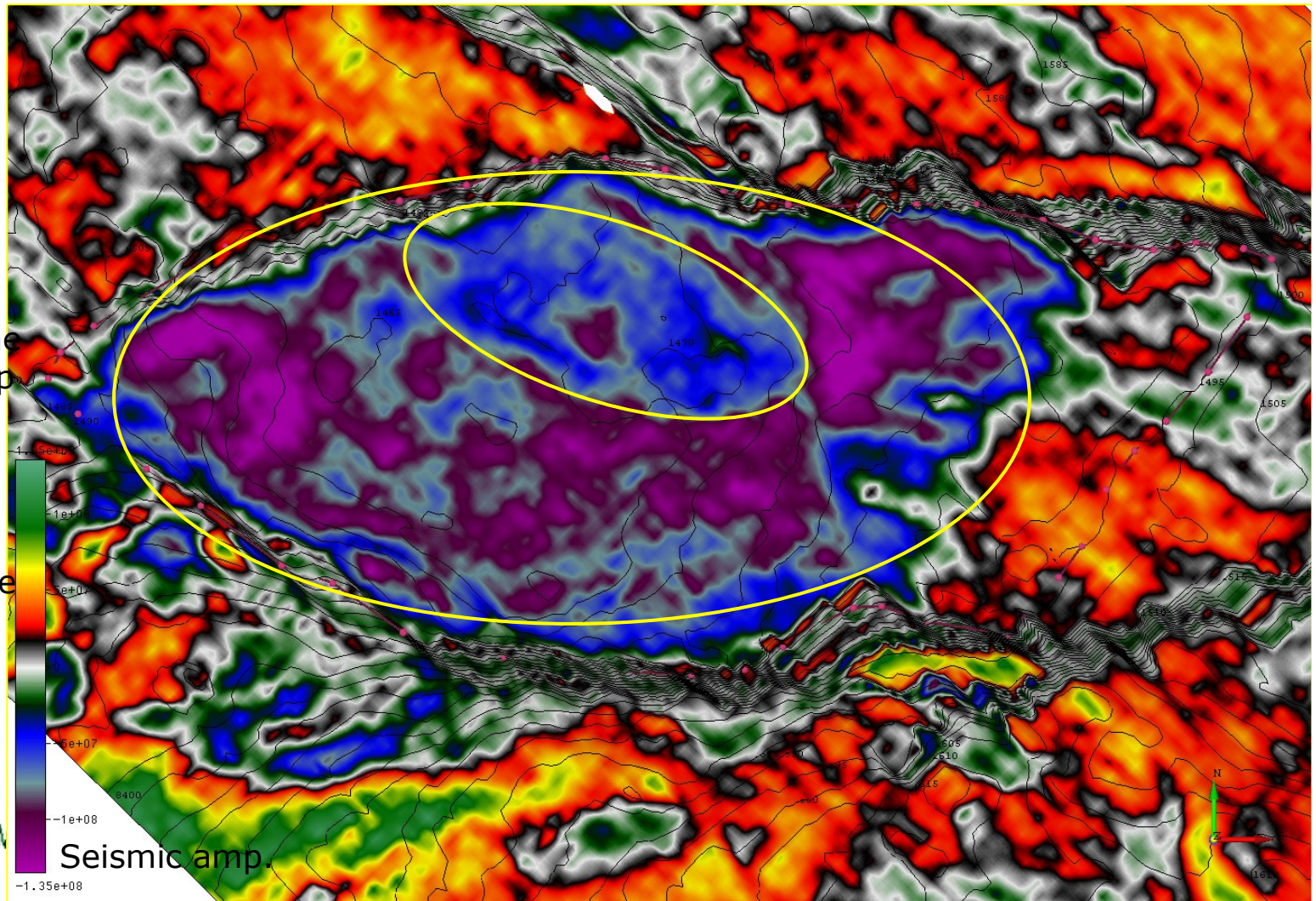


Seismic amplitude map at Base Vlieland Shale

A large low
amplitude area is
visible in the
northern part

It does not
correspond
completely with the
time structure map

A second larger
area show a quick
amplitude decrease
with polarity
reversal





CCB Stack, Area = entire survey Base Vlieland Shale

The following observations can be made:

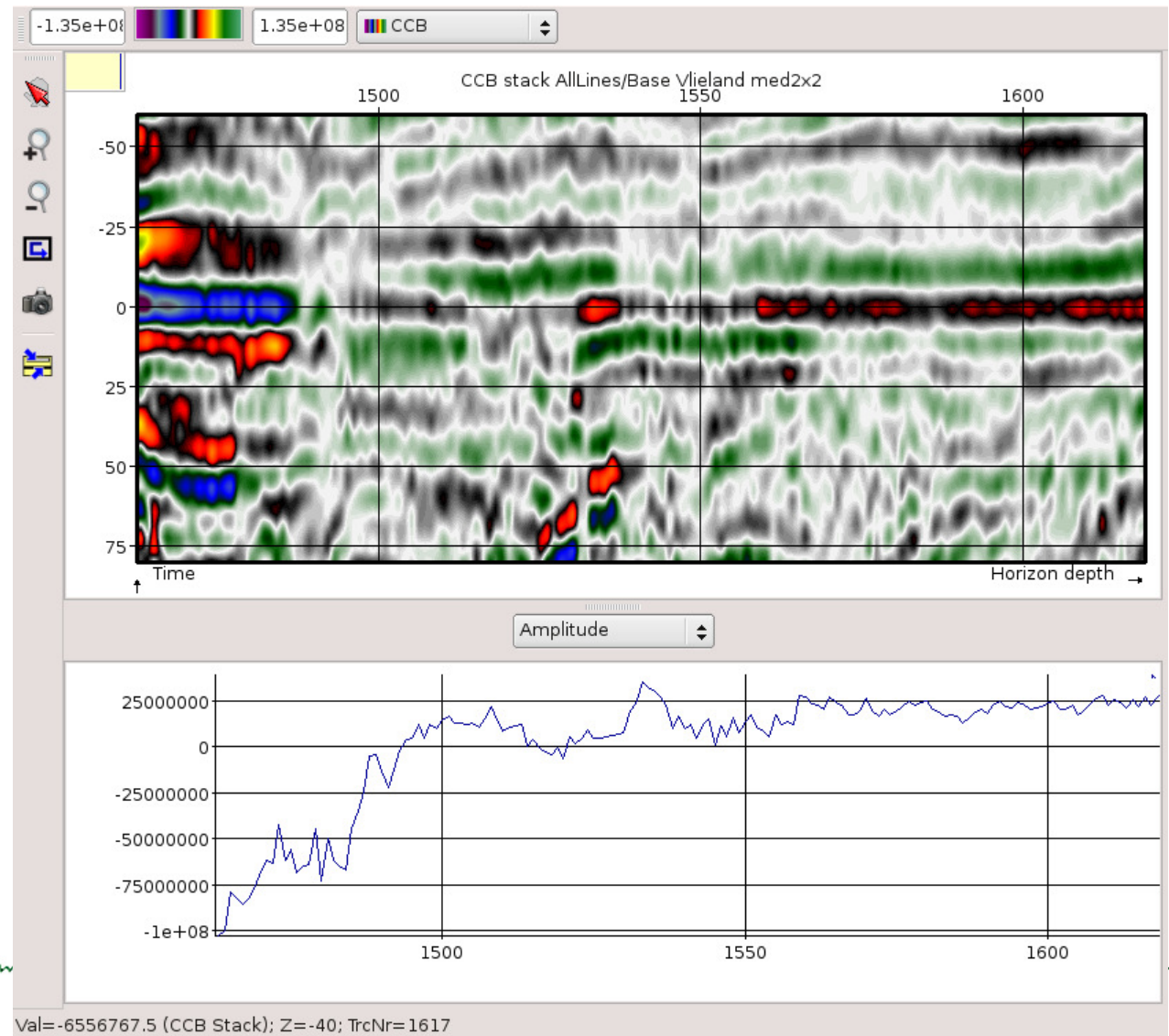
1465ms: Drop of amplitude by 20%

Low amplitudes between 1465 and 1475ms

Much larger drop of amplitudes between 1482 and 1492ms

Besides the small changes around 1465 ms an enormous amplitude change with phase reversal is observed.

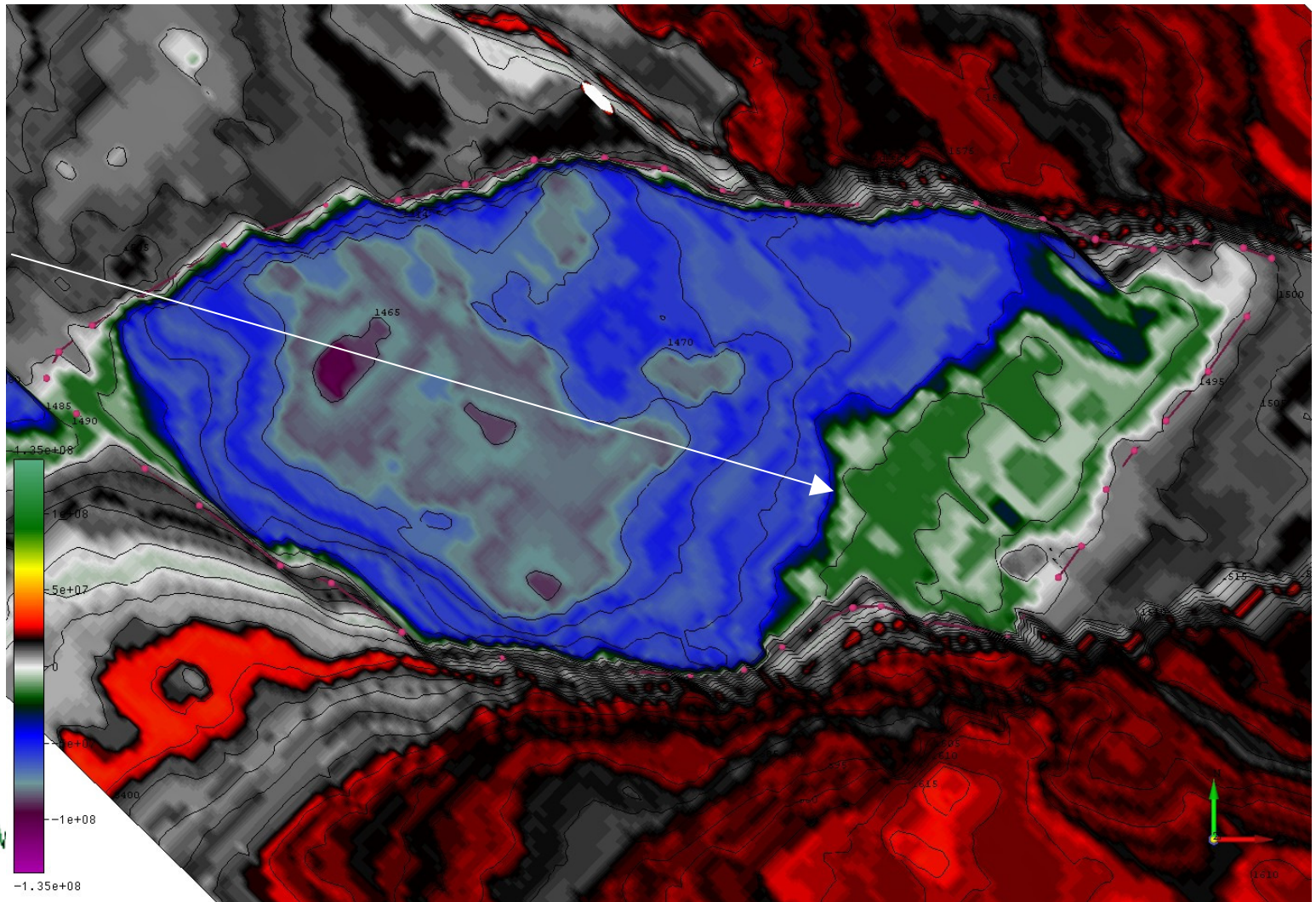
This change is not step-like but the inflexion point is located at 1486 ms. The change occurs within +/-2ms.





CCB Stack amplitude map Base Vlieland

The large
amplitude change
is marked as the
limit between the
blue and green
areas





Conclusions

Base Vlieland Shale

- The CCB stack pattern features two amplitude anomalies at 1465 and 1486ms.
- The amplitude change at 1465 ms is very subtle and cannot be confirmed on time data.
- The large amplitude anomaly at 1486 ms is considered typical behaviour for a CCB stack and could be interpreted as the position of the expected gas/water contact.
- This fluid contact has been confirmed by drilling: Prior to drilling the flat spot was estimated at 1496ms. The GWC in the well was actually found at 1489ms, much closer to the CCB estimation.





Outline

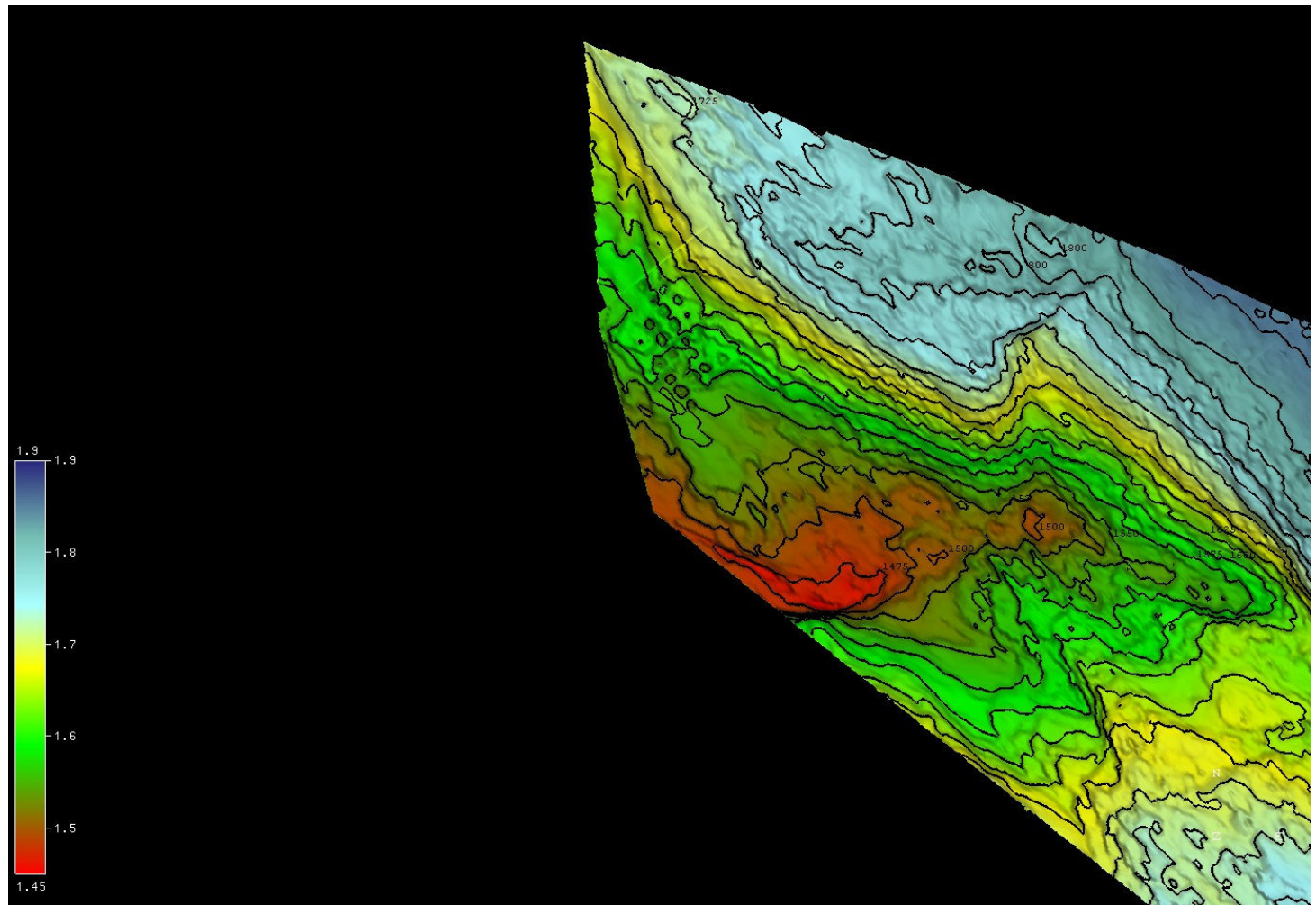
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Top Middle Bunter

Contours every 25ms



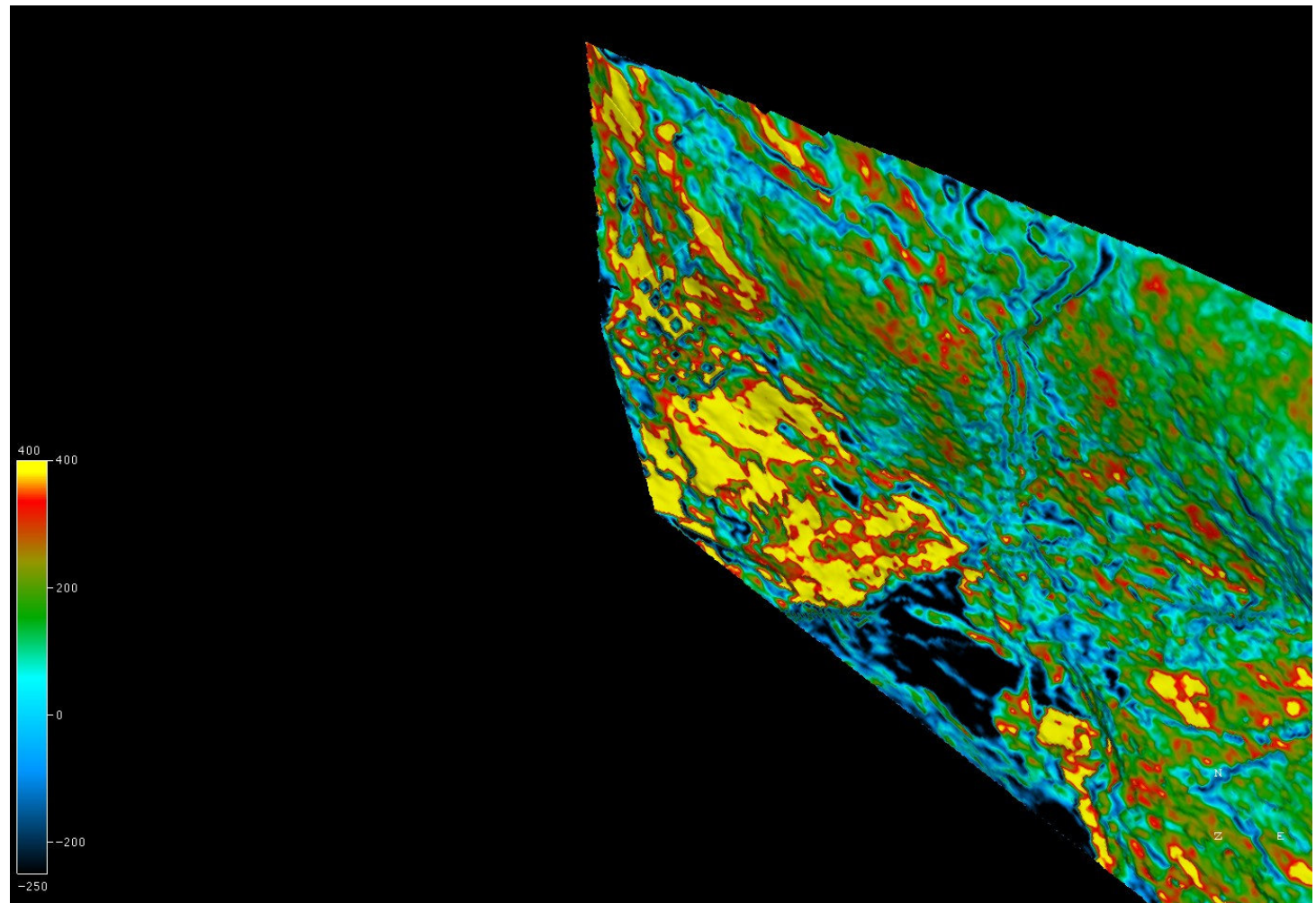
TWT in s.





Seismic amplitude map at Top Middle Bunter

The top of the
structure features
high amplitudes



Seismic amp.



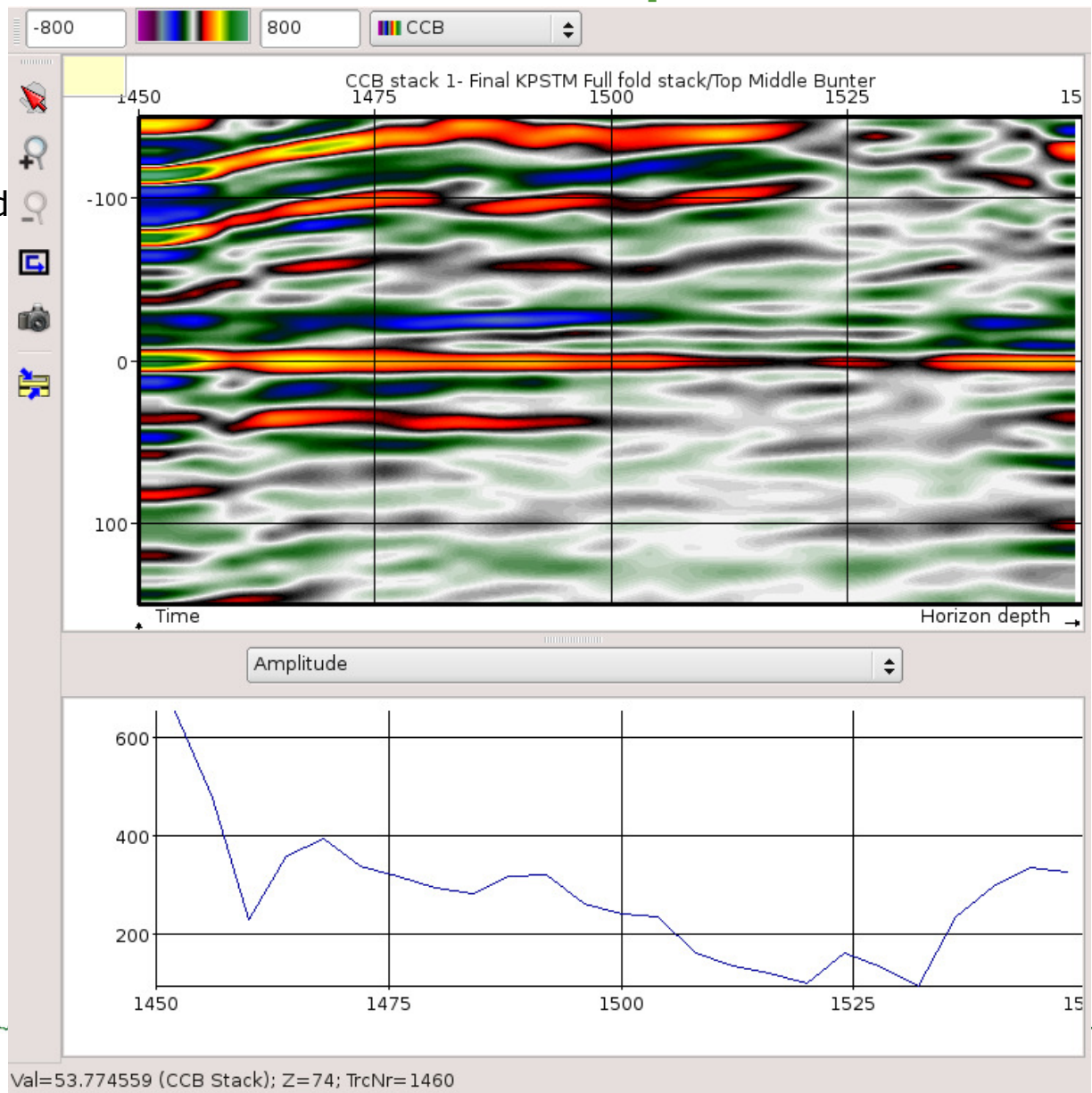


2D CCB Stack Top Middle Bunter

The analysis was run in and around the prospect. Its limit is around a bin depth of 1508ms.

The CCB stack reveals a trend of decreasing amplitudes wrt bin depth.

Nevertheless no clear amplitude change is visible.





Conclusions

Top Middle Bunter

- ✦ The CCB stack at Top Middle Bunter shows smooth variations in amplitudes, somewhat decreasing with bin depth.
- ✦ This behaviour does not correspond to a saturation change in a formation whose thickness is above tuning resolution.
- ✦ Decreasing/increasing amplitude with bin depth can be related to both thickness and saturation changes. Only forward modelling can distinguish them, hence common contour binning is not conclusive at Top Middle Bunter.





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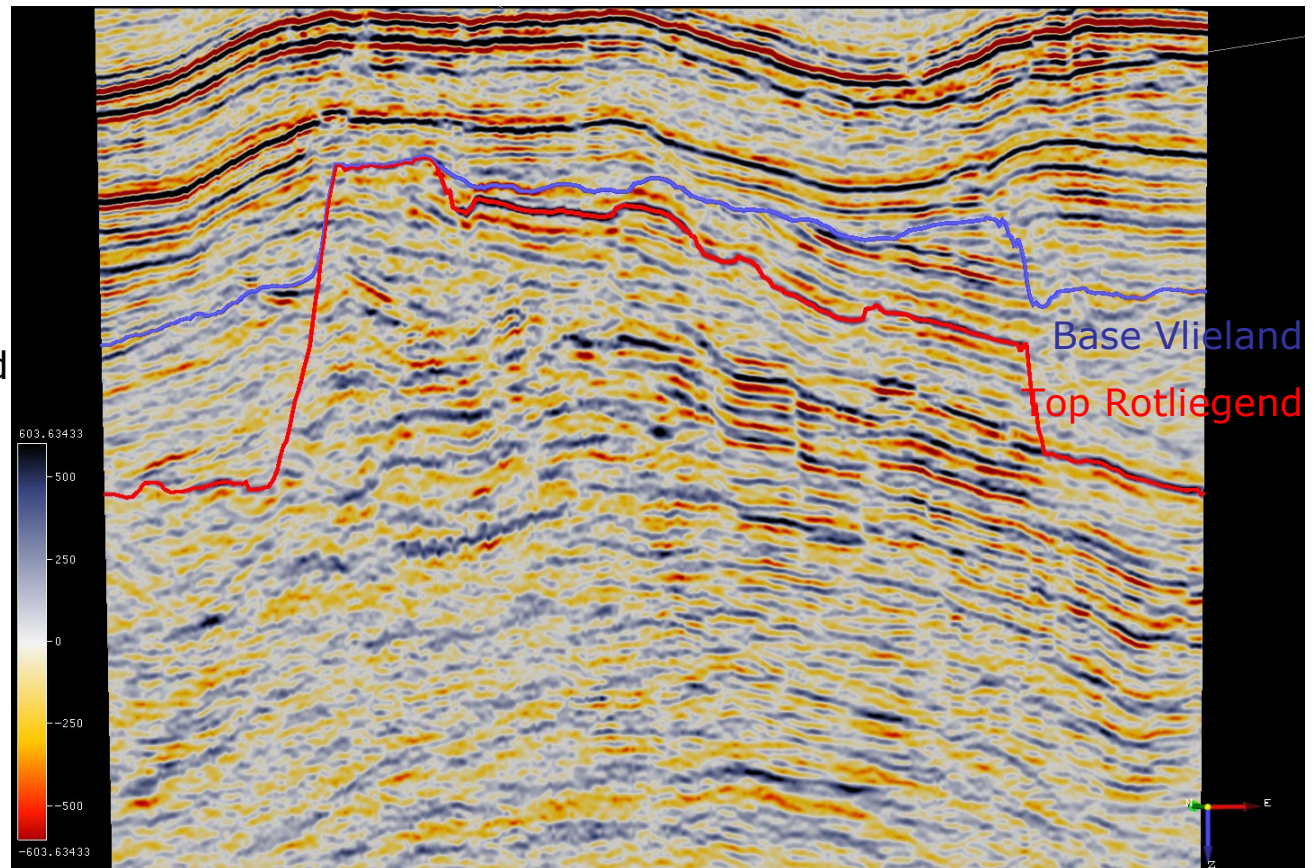




Seismic data, random line through prospect

5 km² (Rotliegend prospect)

The Middle Bunter which is between Vlieland and Rotliegend is completely eroded at the top of the structure.





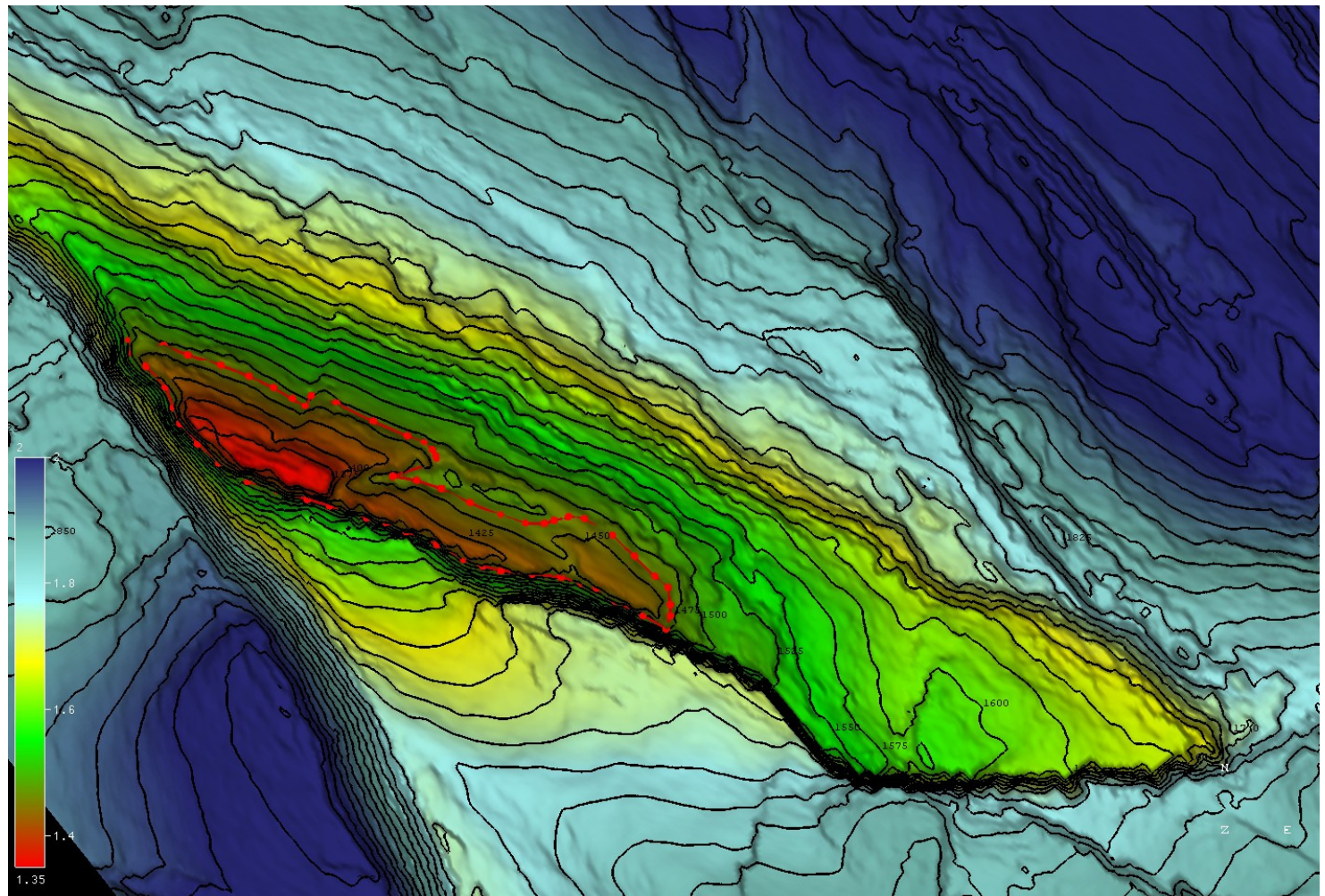
Top Rotliegend

The red polygon is delimiting the area of interest

Contours every 25ms

East-west size (prospect): 10 km

Two areas are visible within the prospect, clearly separated by a normal fault with a 70ms offset at top Rotliegend.



TWT in s.

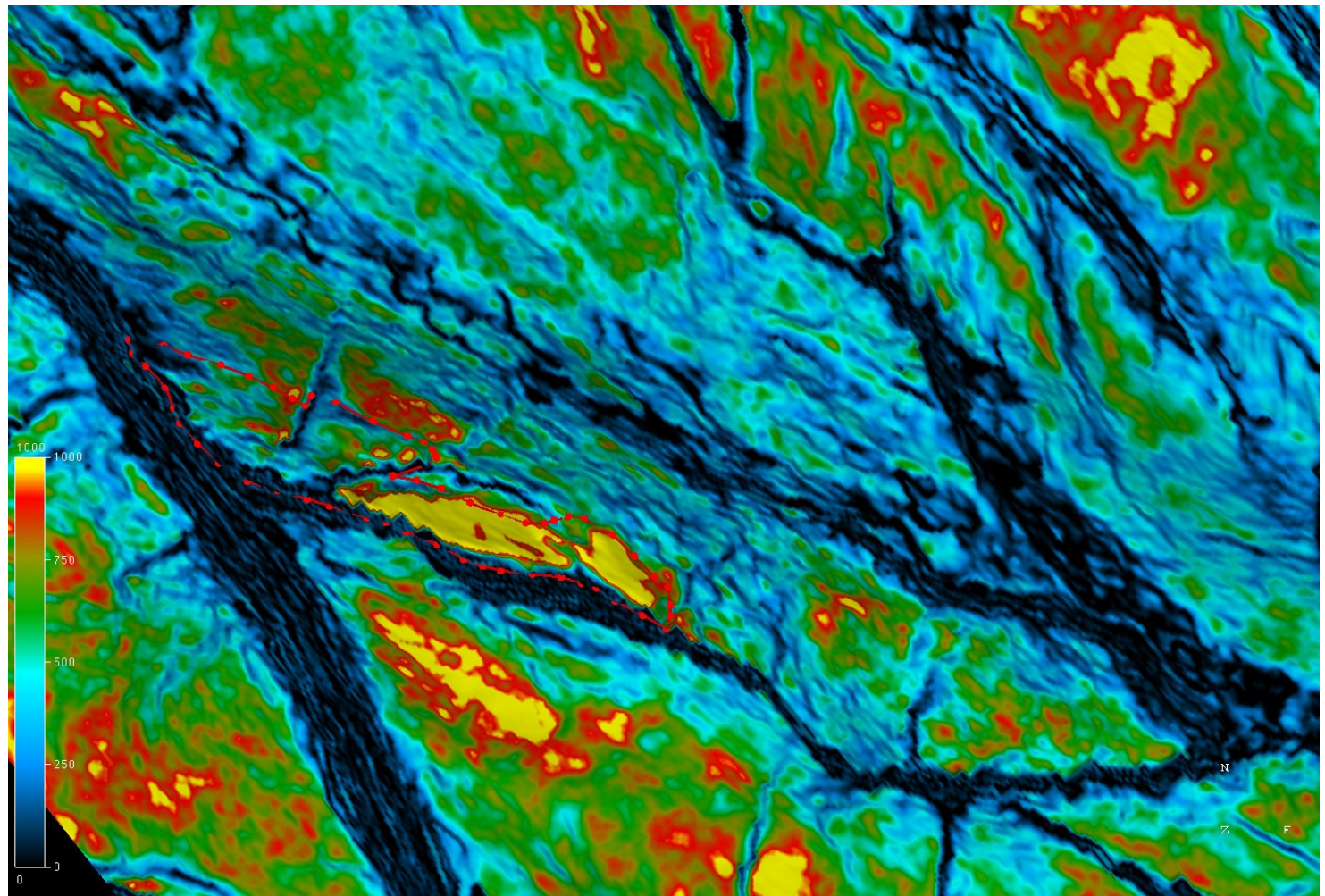




Seismic amplitude map at Top Rotliegend

Several blocks are visible within the prospect.

The crest features lower amplitudes than the south-eastern part.



Seismic amp.

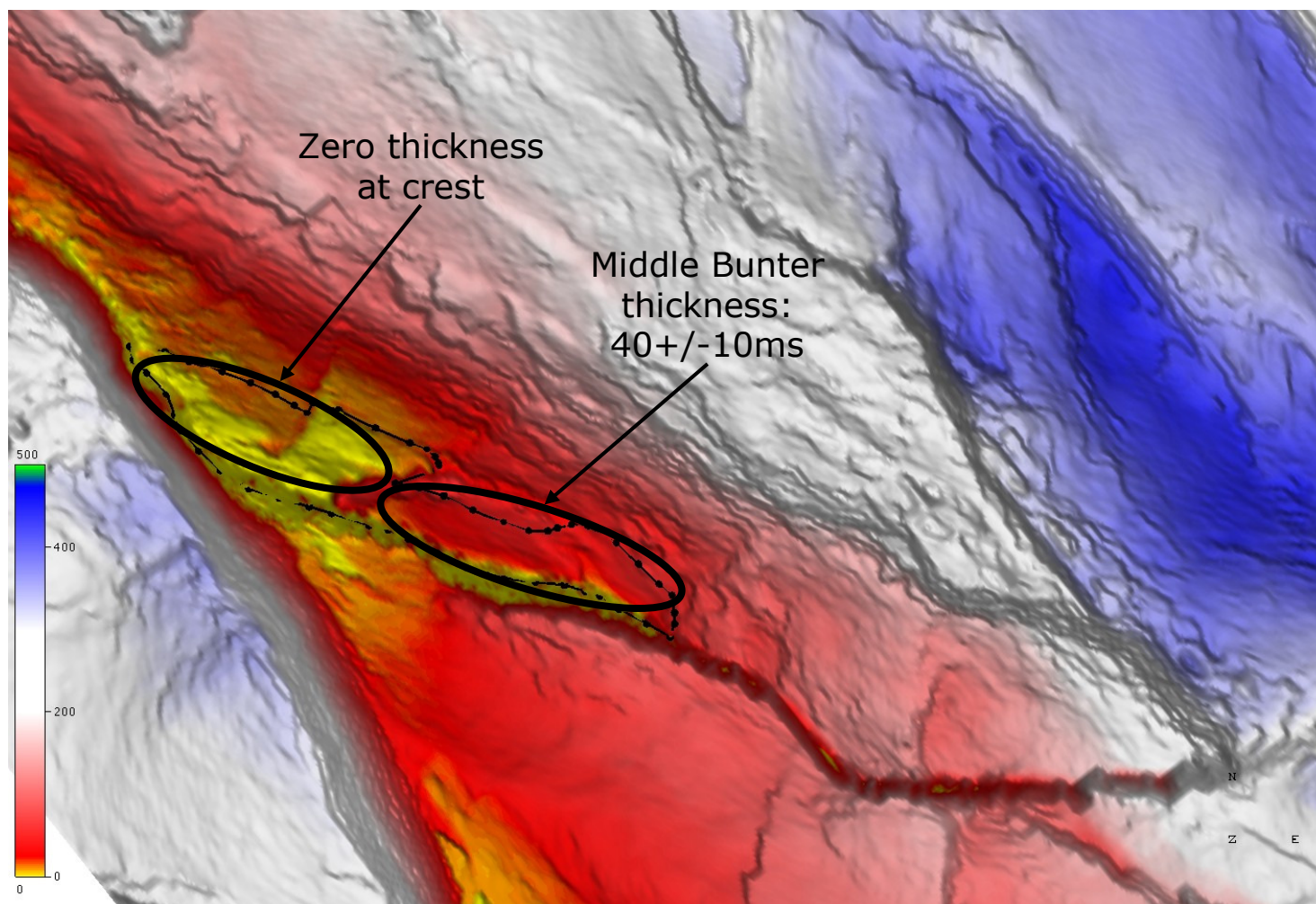




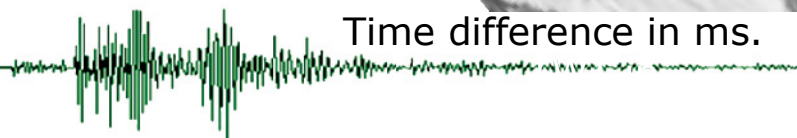
Isopach Top Rotliegend - Base Vlieland Shale

Several blocks are visible within the prospect.

The high amplitudes are located in the part where there is an intermediate formation between Vlieland and Rotliegend, around 40ms TWT in thickness.

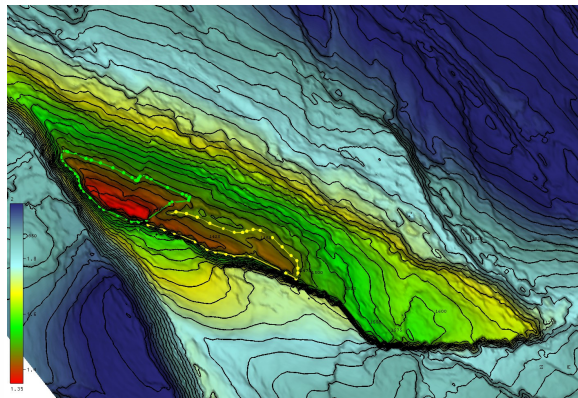


Time difference in ms.



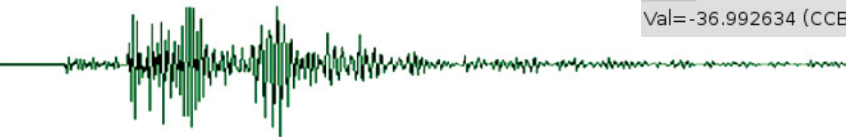
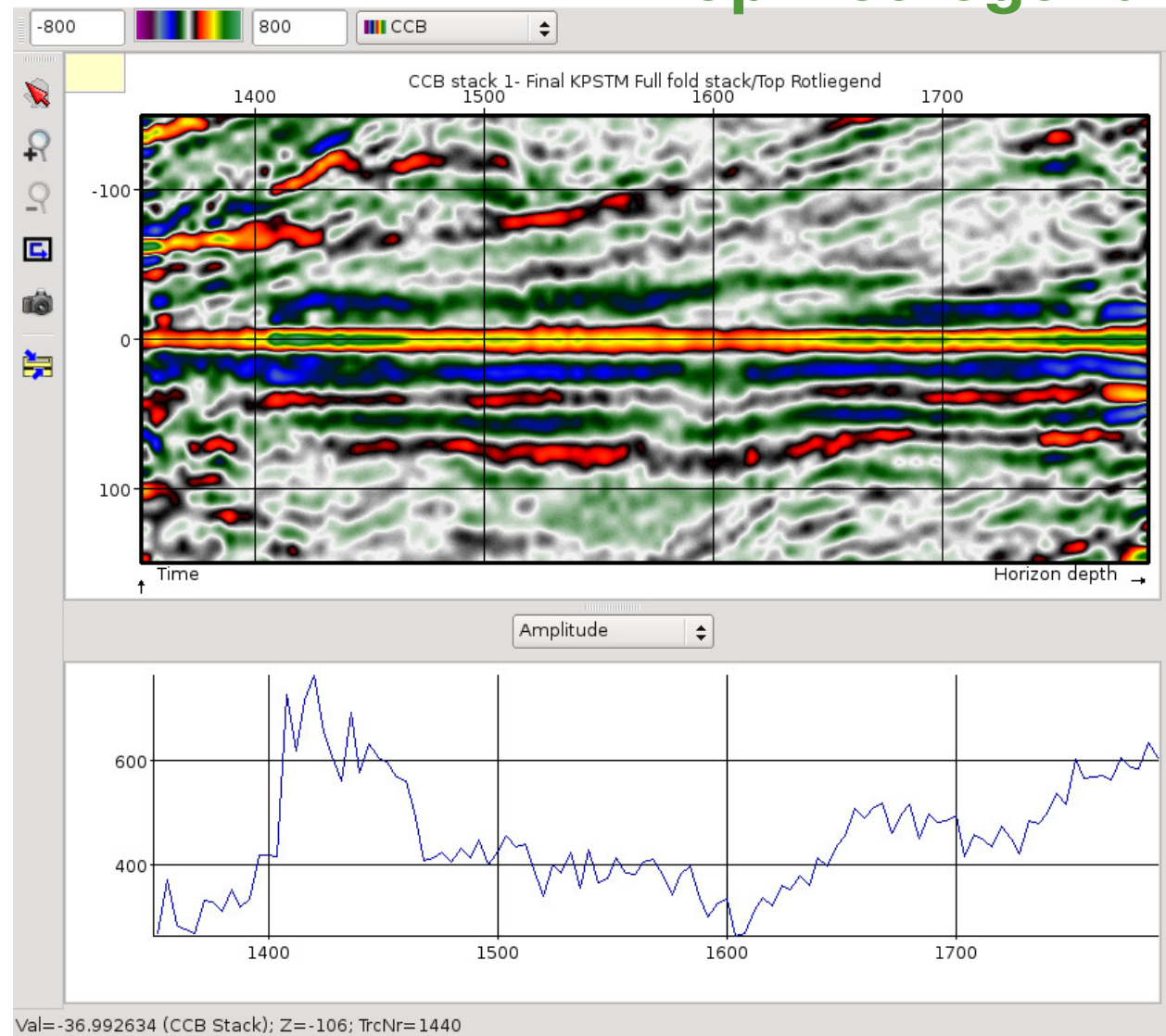


CCB Stack, Area = all Top Rotliegend



The bin depths outside (thus deeper than) the prospect show again low amplitudes.

The outer part of the prospect and observed amplitude change is at 1464ms TWT.





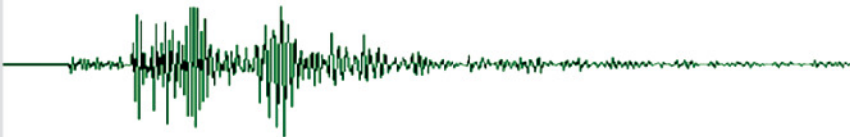
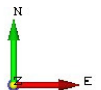
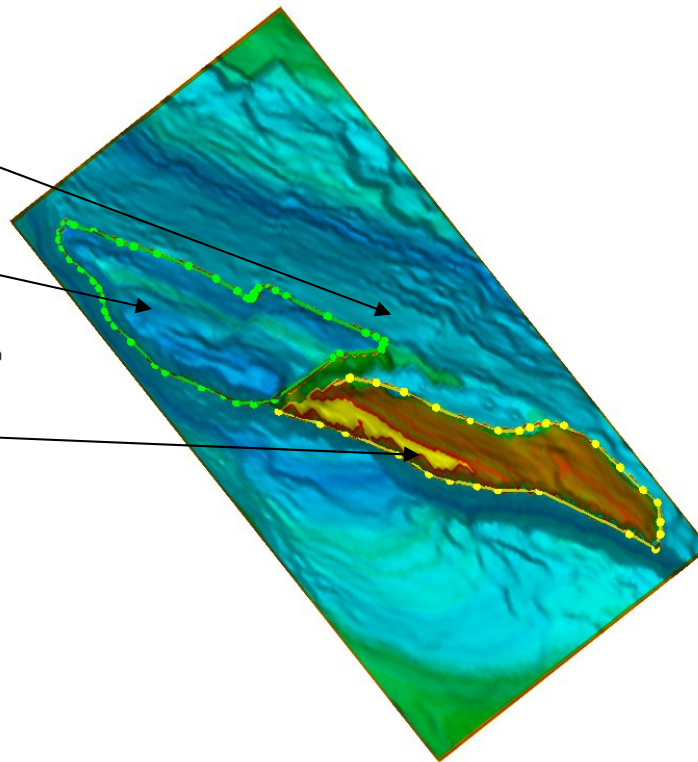
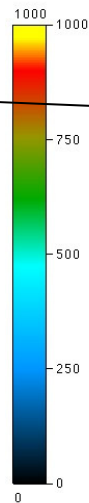
CCB Stack amplitude map Top Rotliegend

CCB Stack combined from the 3 sub stacks

Deep areas:
Low amplitudes

Top of the structure:
Low amplitudes

Second structure:
High amplitudes

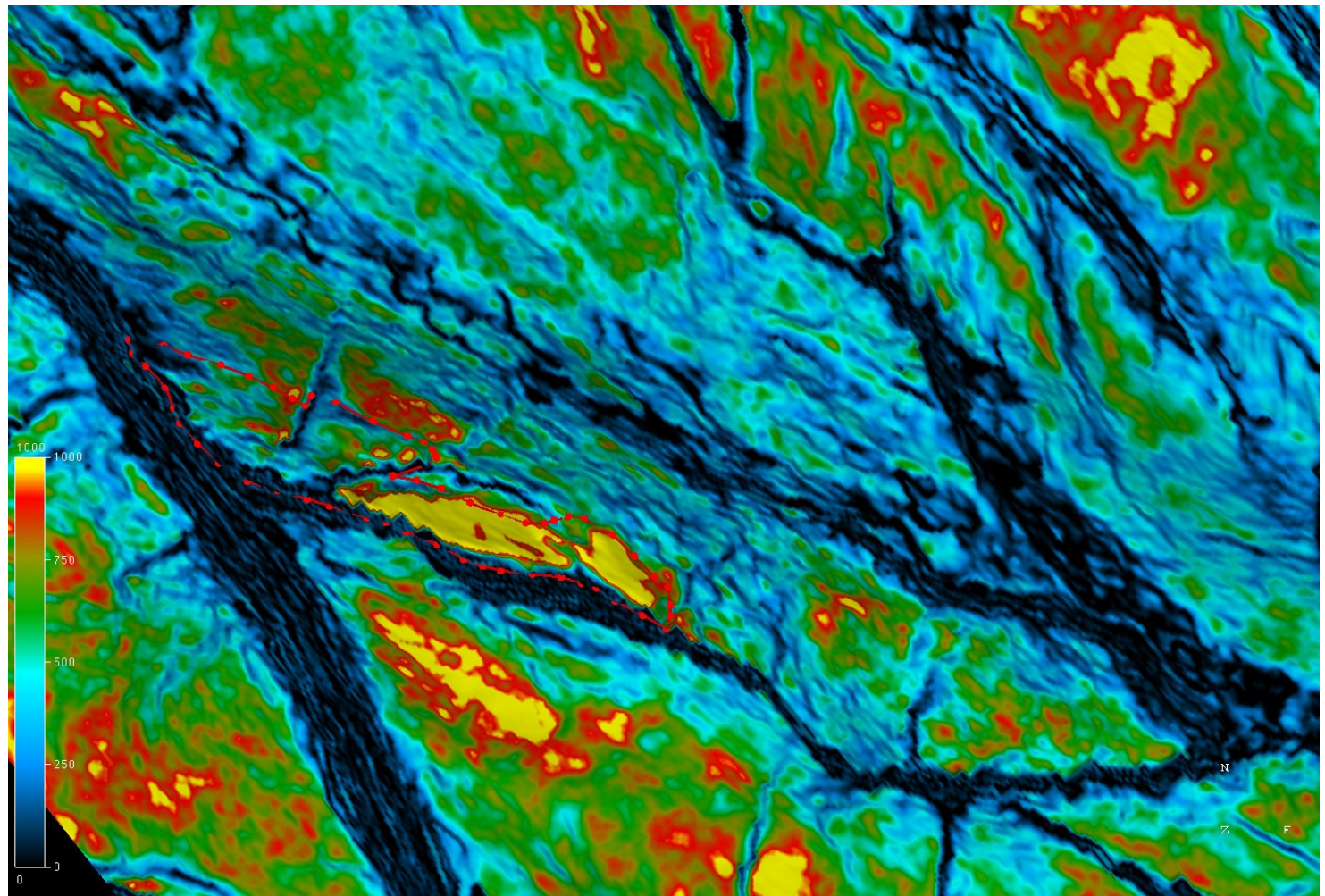




Seismic amplitude map at Top Rotliegend

Several blocks are visible within the prospect.

The crest features lower amplitudes than the south-eastern part.



Seismic amp.





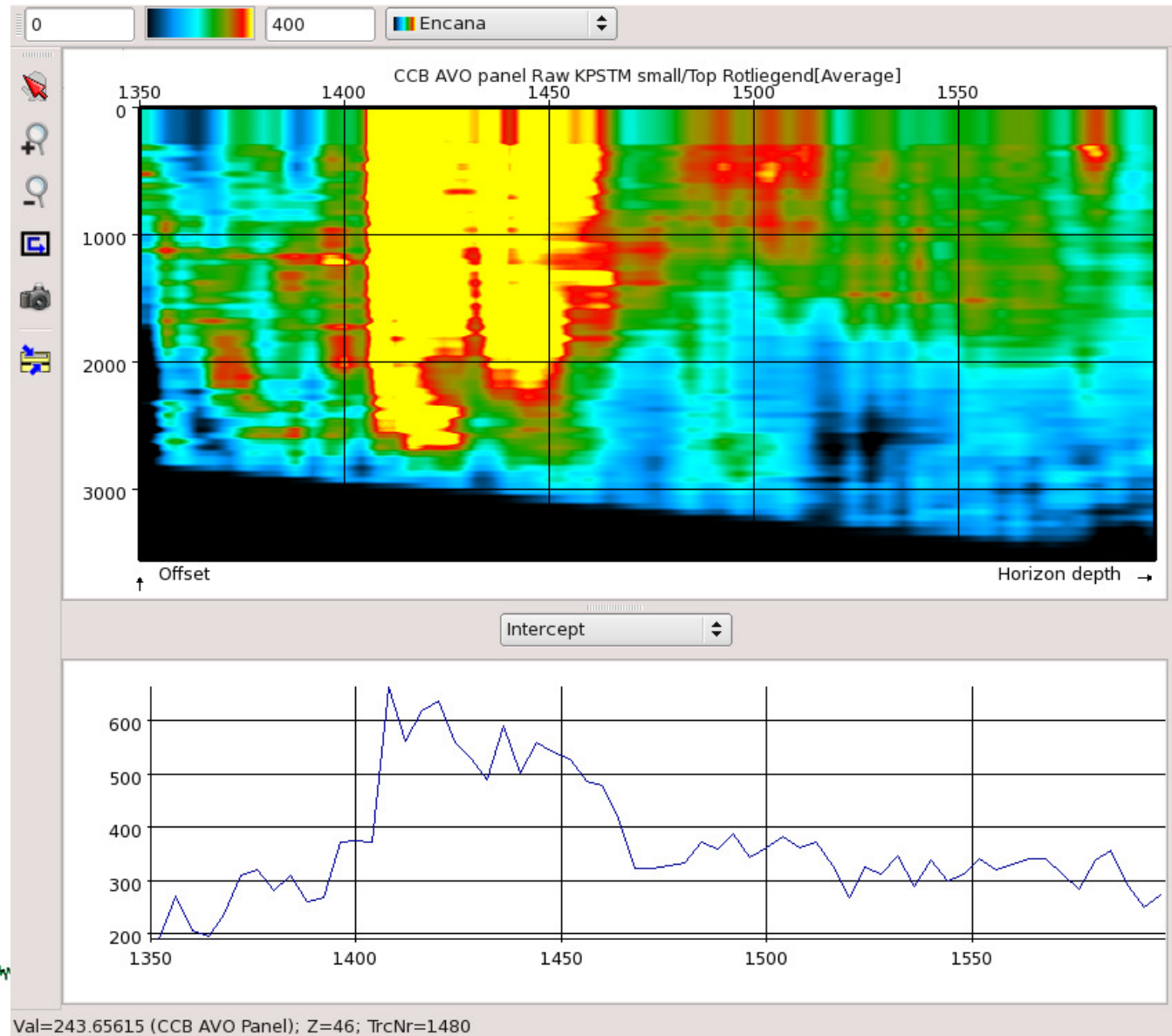
Pre-stack CCB Top Rotliegend

CCB was applied to pre-stack data. The technique works similarly with offset as extra dimension.

The display is limited to the horizon Z only.

The vertical axis represent offsets (in m.) while the colours remain seismic amplitudes.

A classical AVO graph would be a vertical slice on that panel.





Conclusions

Top Rotliegend

- CCB stacking highlighted clear amplitude changes at 1406 and 1464ms TWT, from the post and pre-stack data.
- The structure is divided in two by a normal fault that appears to be a lateral seal, since high amplitudes are observed in the south east compartment that are not present in the crest, neither at the same depth nor shallower.
- Therefore three areas may be distinguished:
 - The crest is a Rotliegend/Vlieland contact, with low amplitudes
 - The outer part of the prospect is a Rotliegend/Bunter contact with low amplitudes.
 - The south-eastern part of the prospect is a Rotliegend/Bunter contact with much higher amplitudes.





Conclusions Top Rotliegend

- While the amplitude change at 1406ms could be attributed to a lithology change rather than to a fluid contact, the second amplitude change at 1464ms cannot be explained by a lithology change based on the available interpretations and the observed structures.
- Therefore the CCB results and structural information indicate that the south-eastern part of the prospect is gas filled with an up-dip seal along the normal fault in the north-west, and a gas-water contact at 1464ms +/-4ms.





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Conclusions

- Common contour binning highlights subtle fluid-related seismic anomalies and allows delineating fluid contacts with more accuracy. However, the technique in isolation cannot uniquely prove the presence (or absence) of hydrocarbons.
- The first and last example showed how gas water contacts can be picked with confidence, at Base Vlieland Shale and Top Rotliegend, respectively.
- However, the second example shows also how difficult the interpretation can be when the amplitude increases or decreases monotonously with bin depth. Such difficult cases cannot be interpreted with merely the application of common contour binning. They require further study including additional structural information and sensitivity analyses.
- Furthermore, there is a significant risk at using this geometrical stacking technique outside of the original depth domain, therefore it is always recommended to go in the depth domain when possible.

