



equinor

Deep Learning Neural Network Solution Applied to Seismic Horizon Interpretation

FORCE ML Symposium

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Acknowledgments

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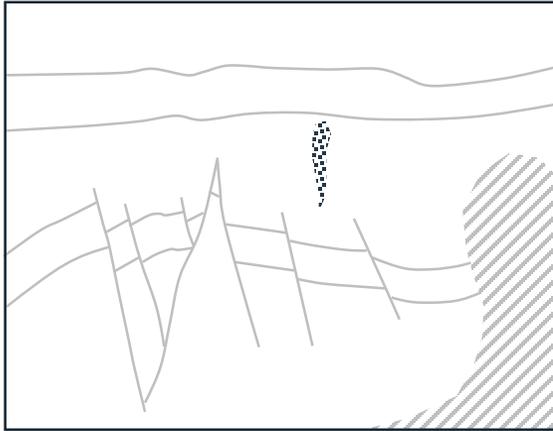


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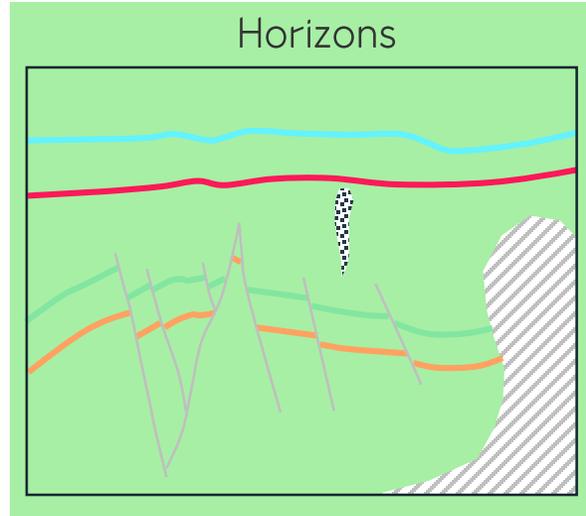


John Thurmond

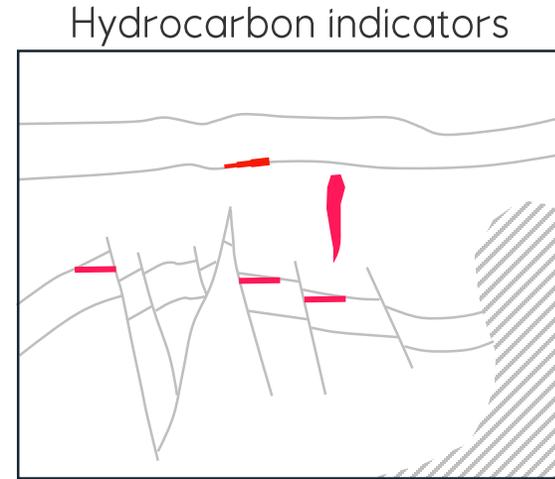
What to target?



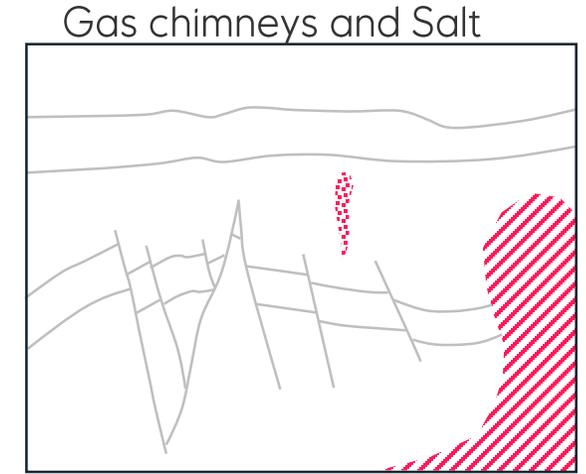
Faults



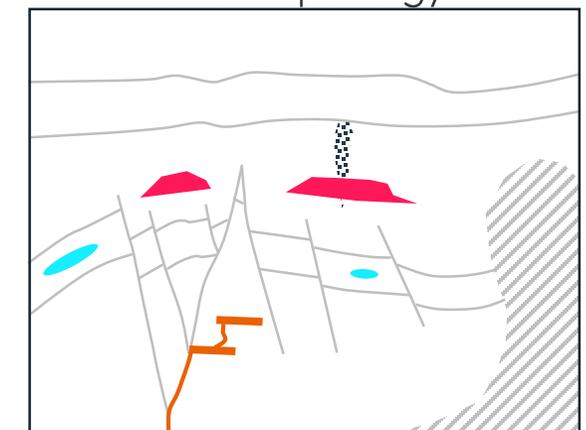
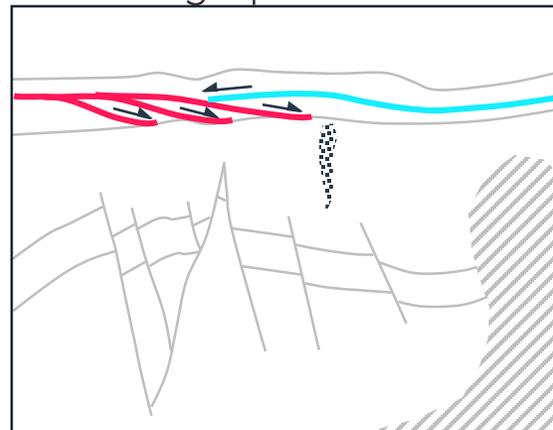
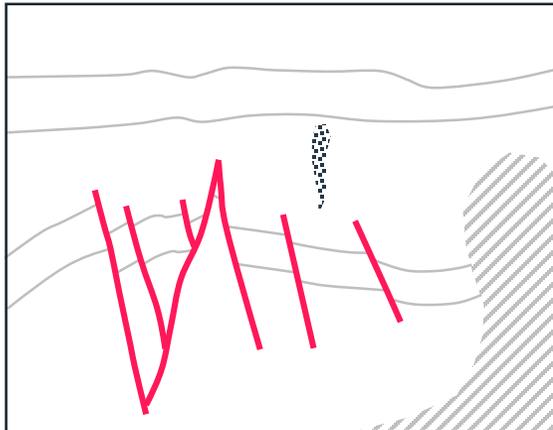
Stratigraphic elements



Facies



Geomorphology



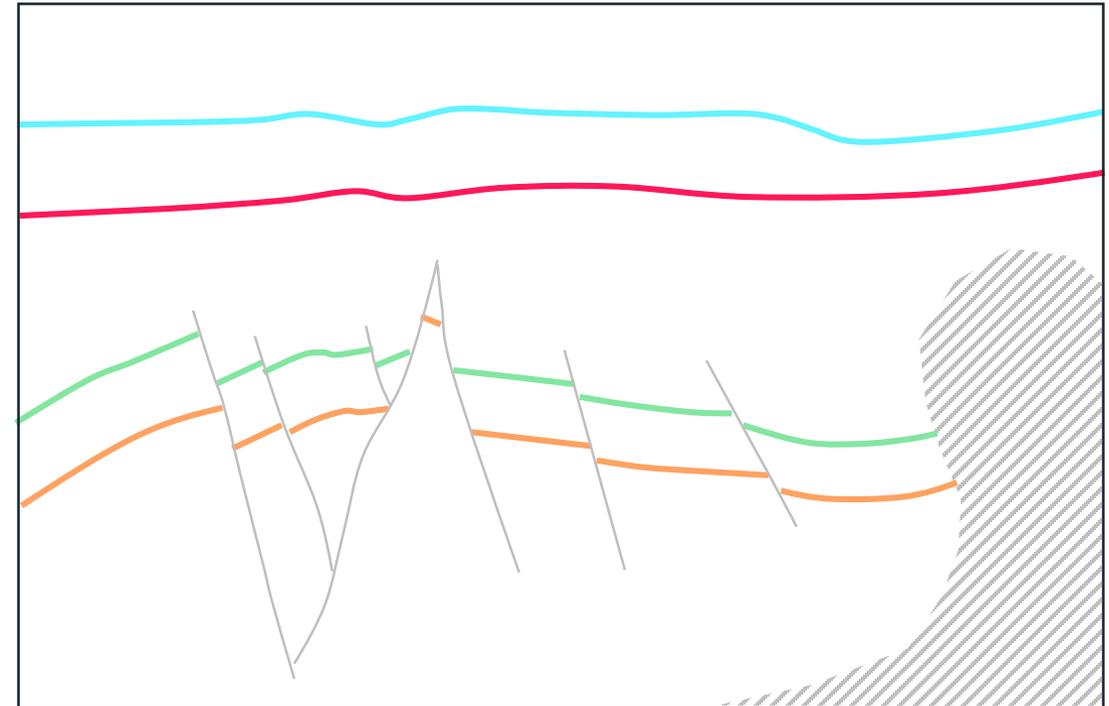
Seismic Horizon Interpretation

Exploration

- Understand the region
- Generate prospects
- Detailed surfaces not always needed
- Key horizon interpretation
 - Easy continuous reflections → Autotracker
 - Complex or subtle reflections → Manual

Production

- Understanding the field in detail
- Focus on reservoir
- Details needed
- Horizon interpretation
 - Mainly manual but autotracker could be used



2D

3D

Segmentation

FCN (Fully Convolutional Network)

SegNet

Unet

Deep Unet

VolConvNet

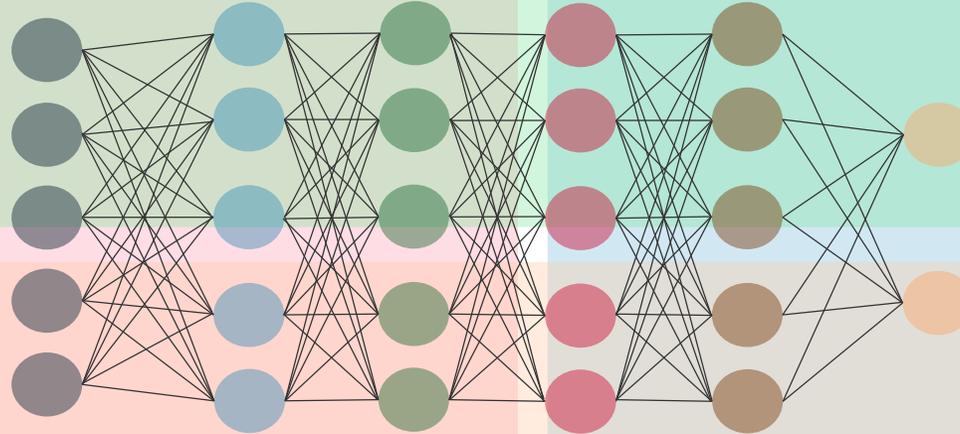
VNet

Detection

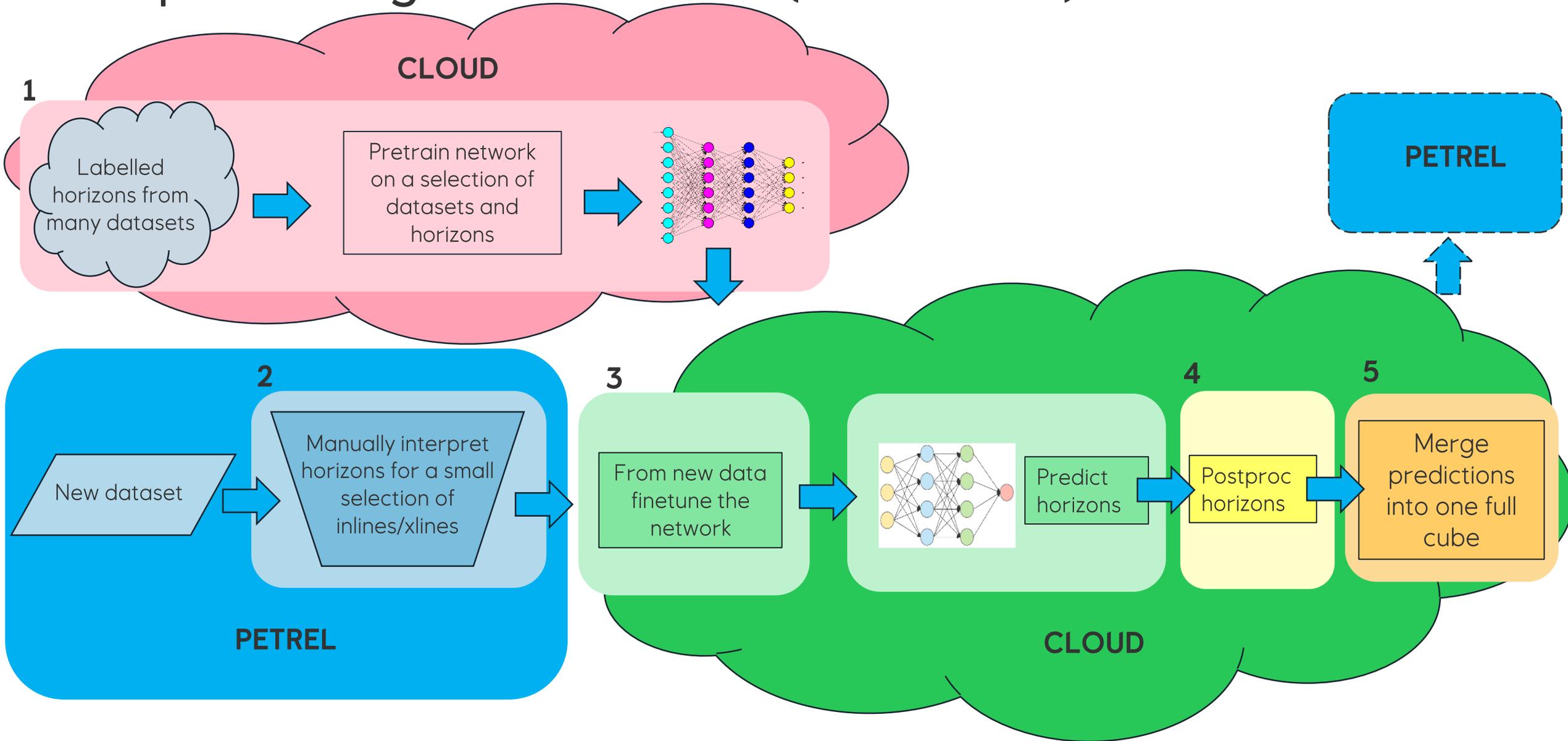
ResNet (pretrained)

CapsuleNet

Salt-detection network



Best performing network so far (HorizonNet)



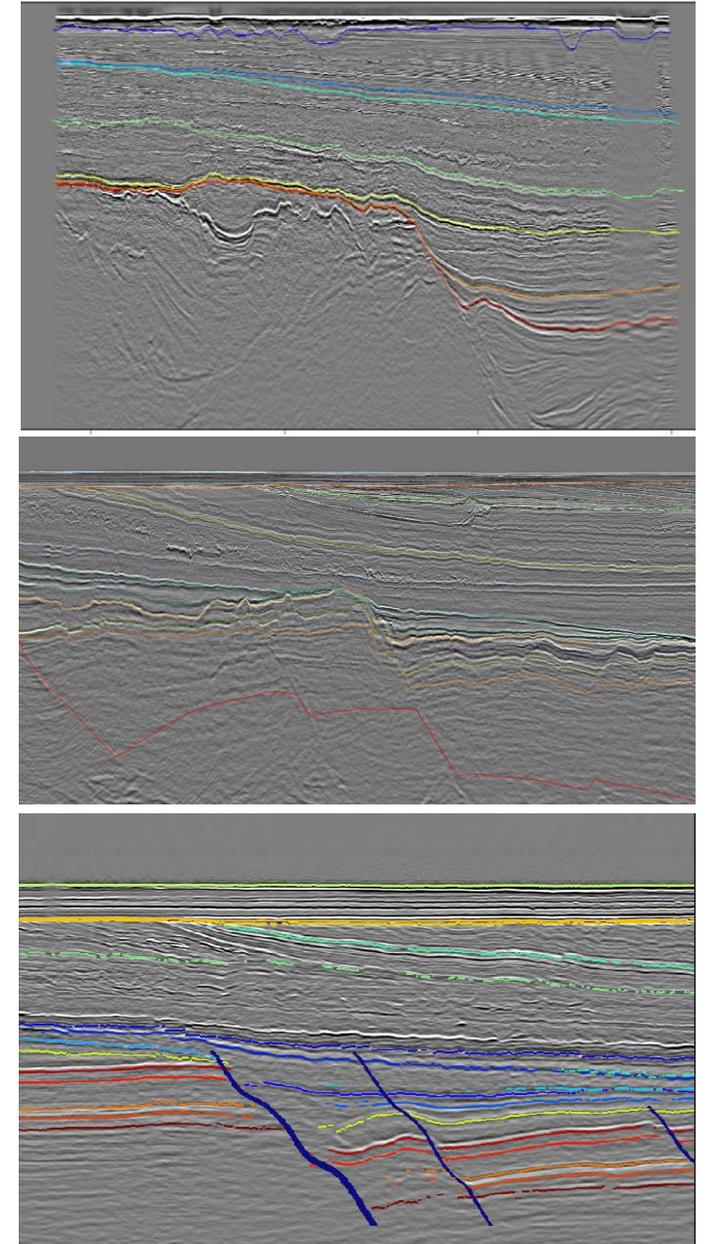
Identifying the correct training data

Challenges:

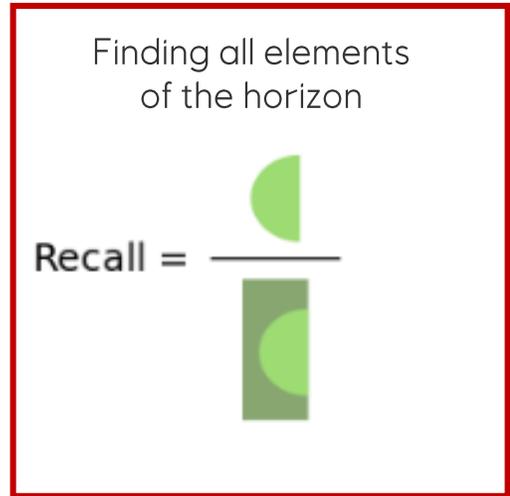
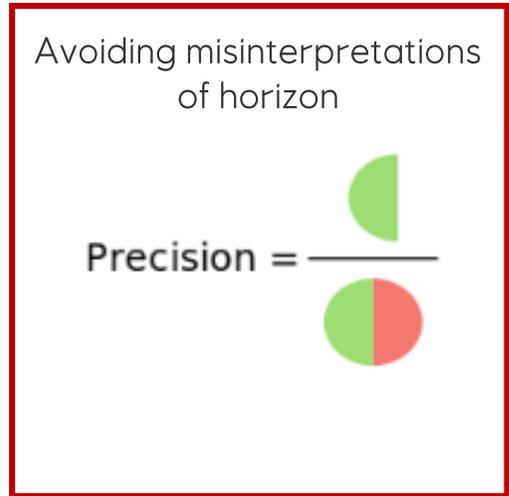
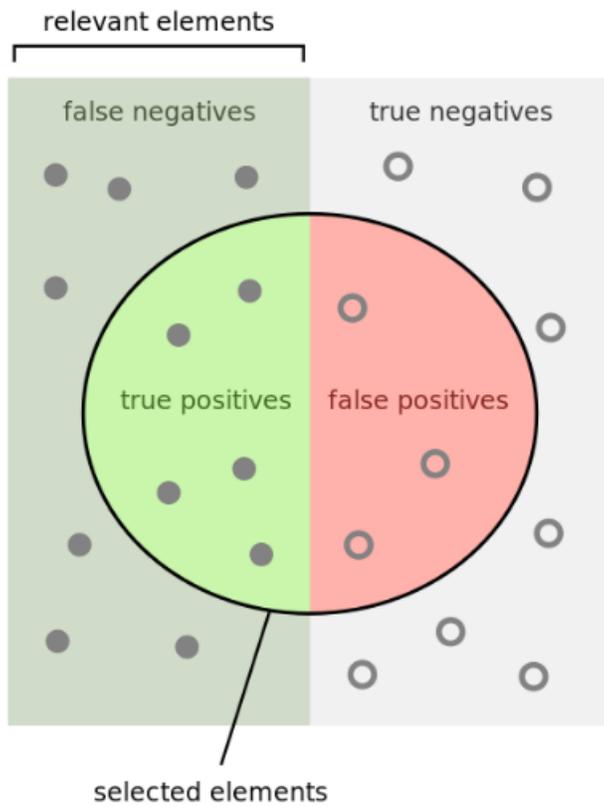
- Varying interpretation quality
- Varying seismic quality and texture
- Different key horizons in each dataset
- Different seismic texture within "same" layer

As a consequence:

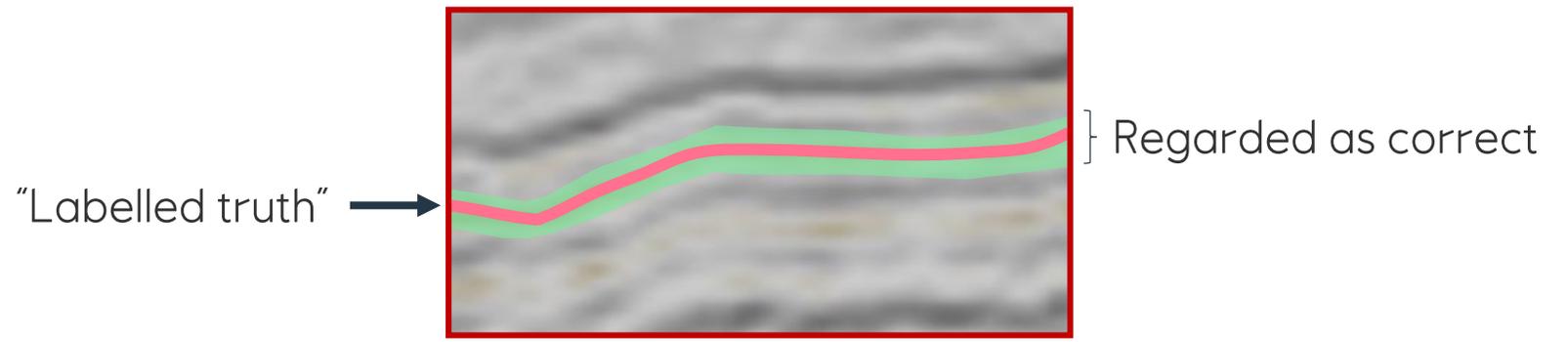
- Started out with synthetics
- Included real data later



How to quantify results?

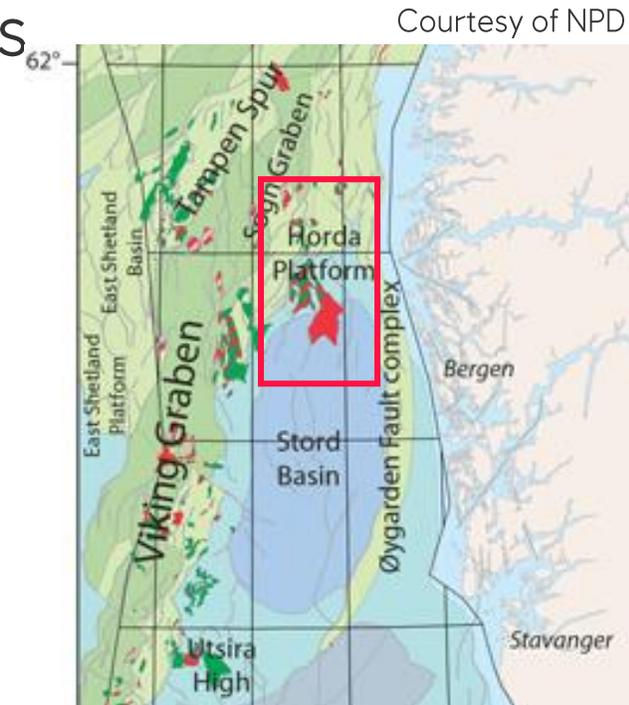


$$F_1 = \left(\frac{\text{recall}^{-1} + \text{precision}^{-1}}{2} \right)^{-1} = 2 \cdot \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}}$$

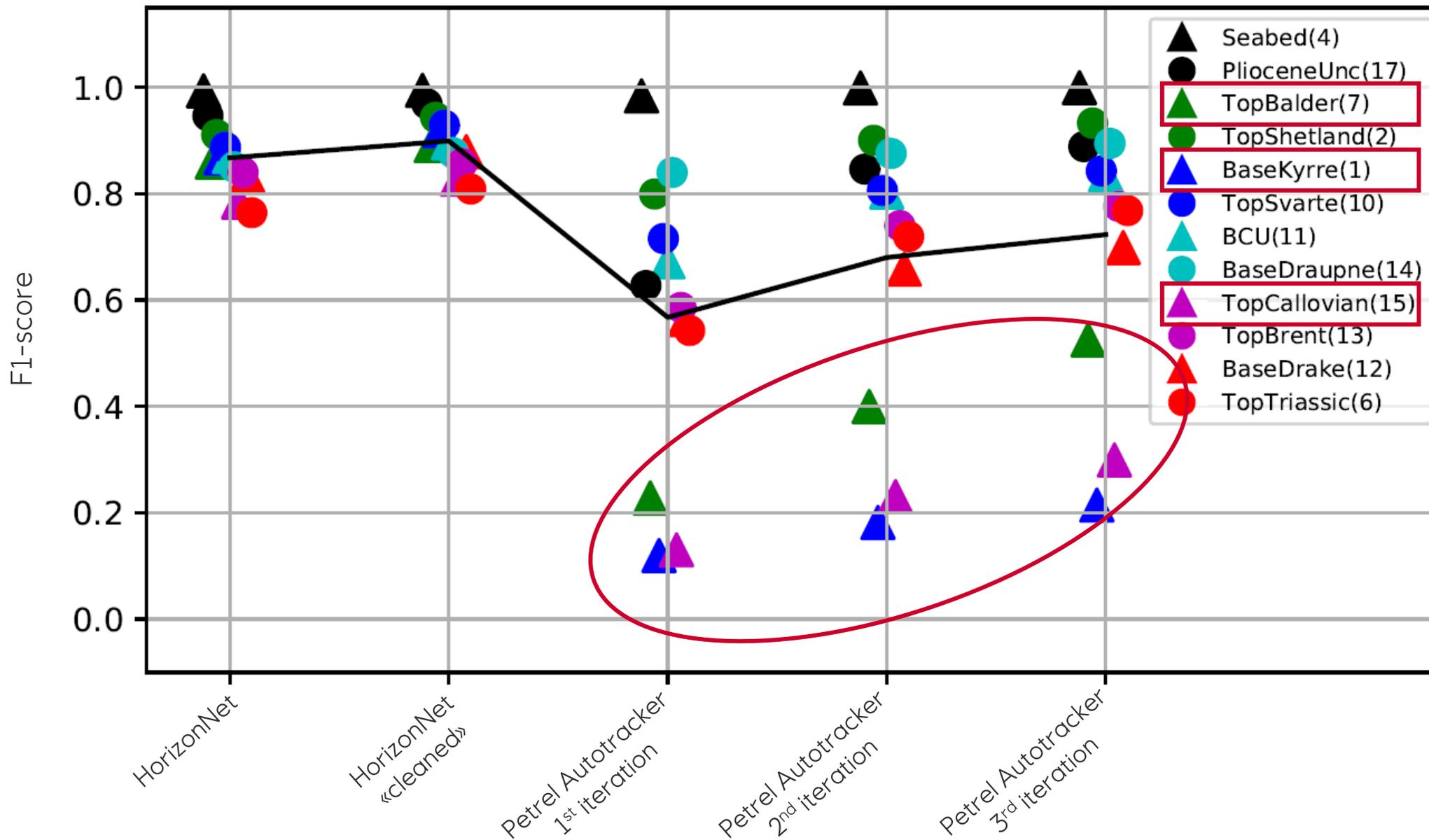


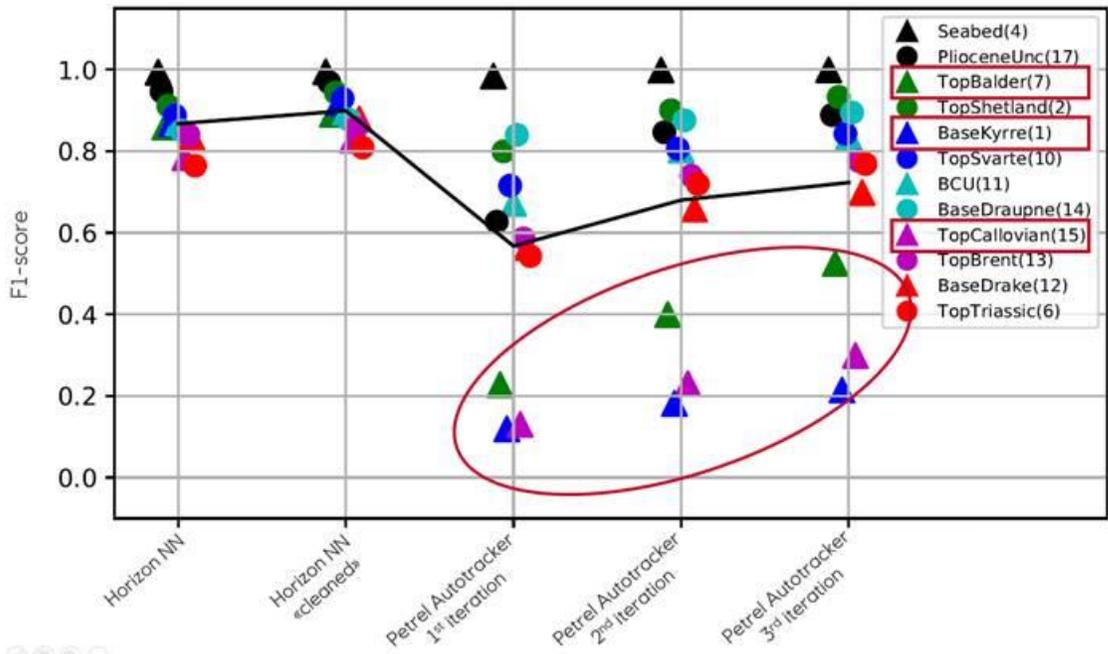
Experiment #1

- 3D CGG Survey from the Horda-platform - Size: 2700 km²
- Some xlines interpreted to finetune the pre-trained network
- Same lines used as input to autotracker for comparison
- Autotracker set conservative - run with 3 iterations
- 12 key horizons interpreted



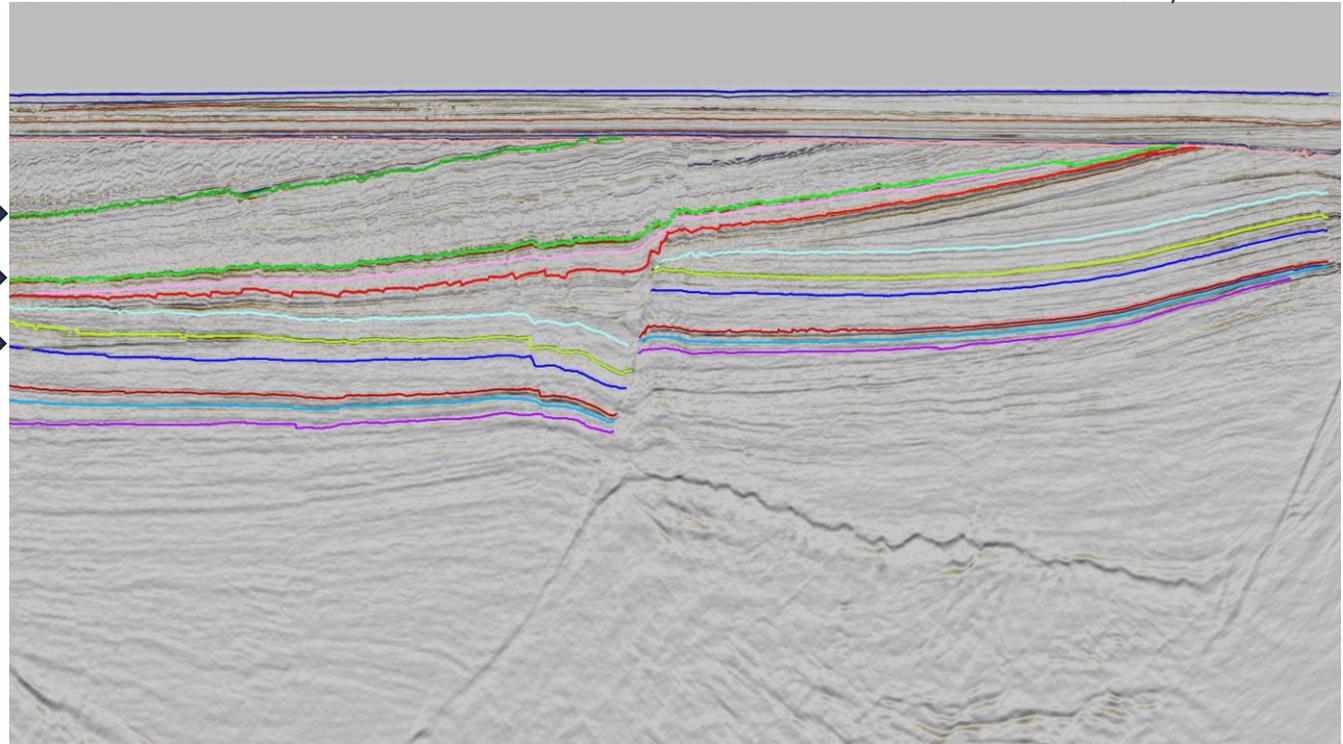
Averaged over all xlines





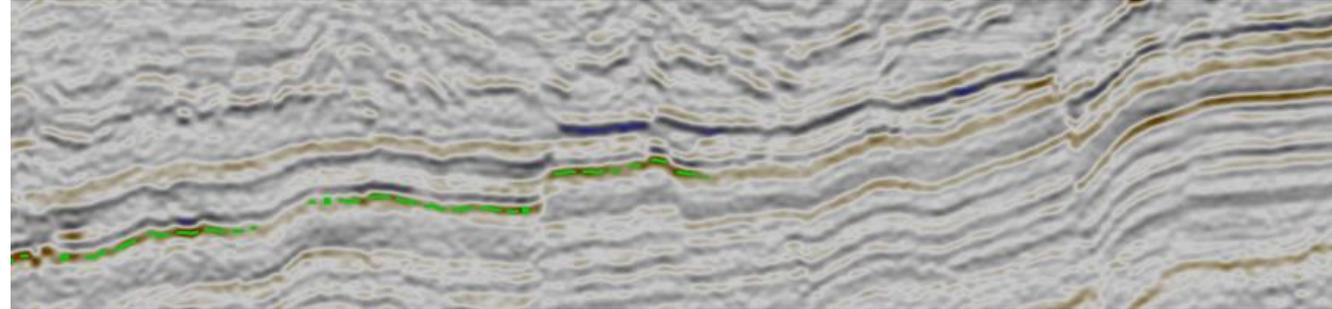
Courtesy of CGG

Top Balder →
 Base Kyrre →
 Top Callovian →

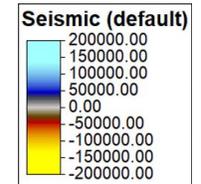
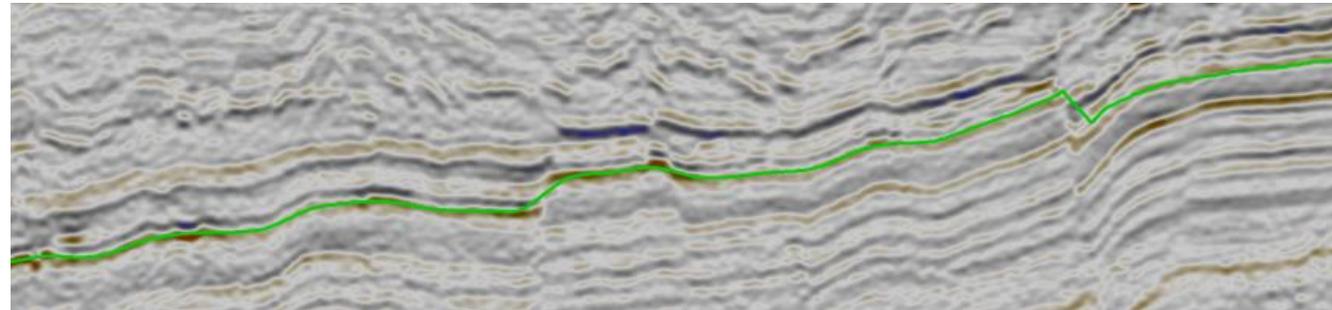


Top Balder – HorizonNet vs Autotracker

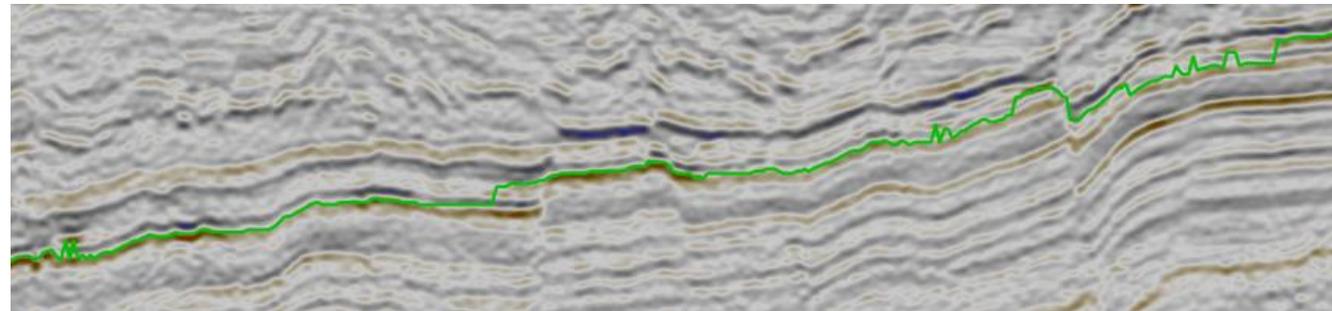
Autotracker



Labelled truth



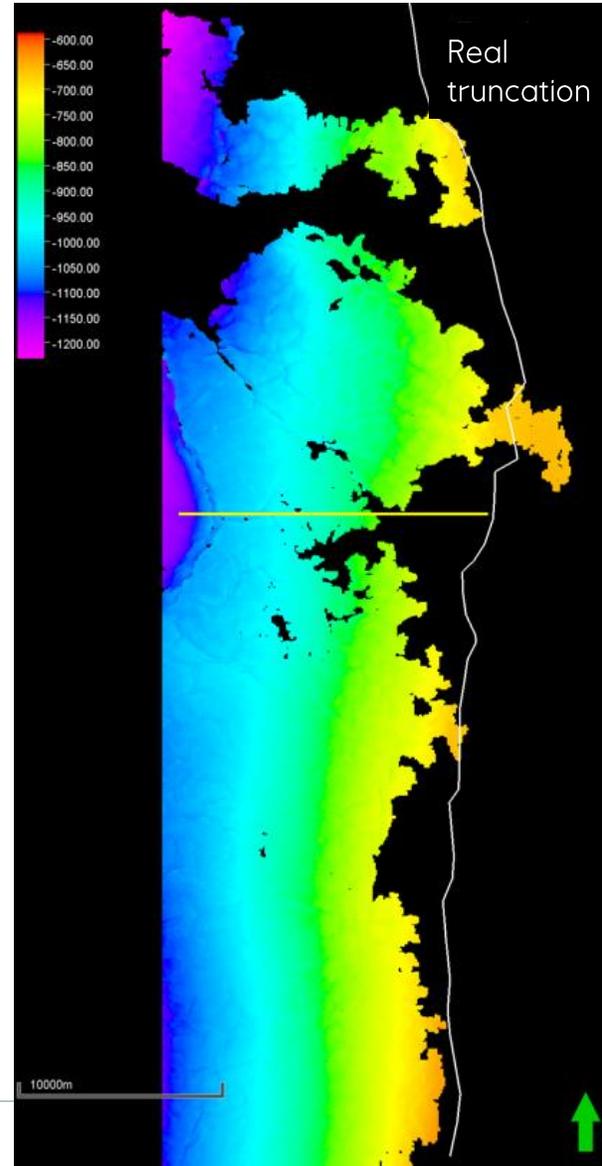
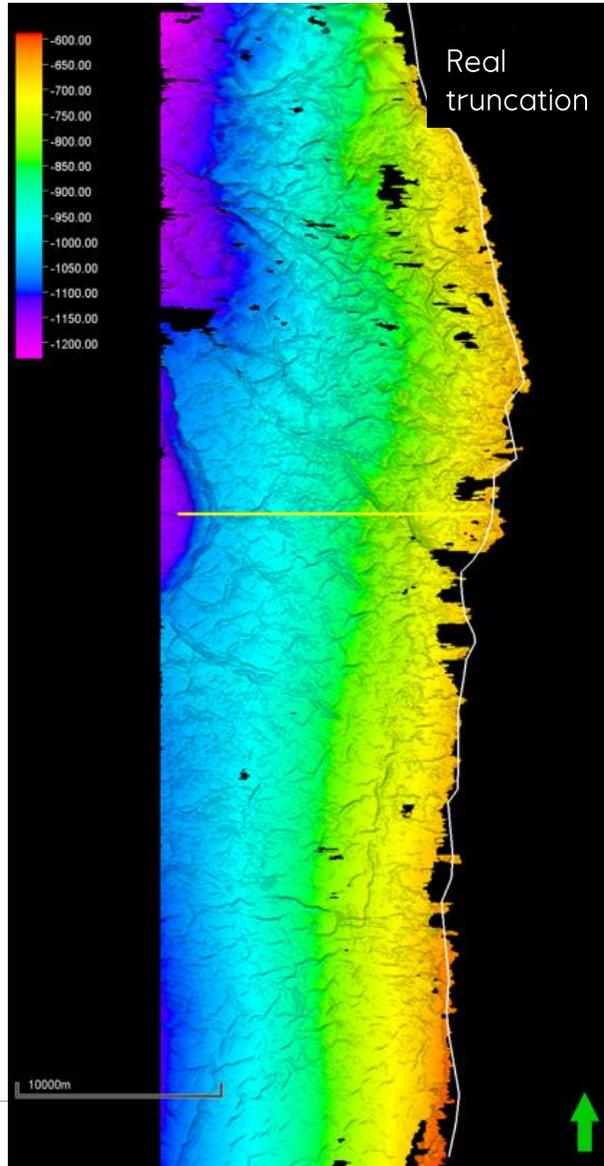
HorizonNet



Courtesy of CGG

Top Balder – HorizonNet vs Autotracker

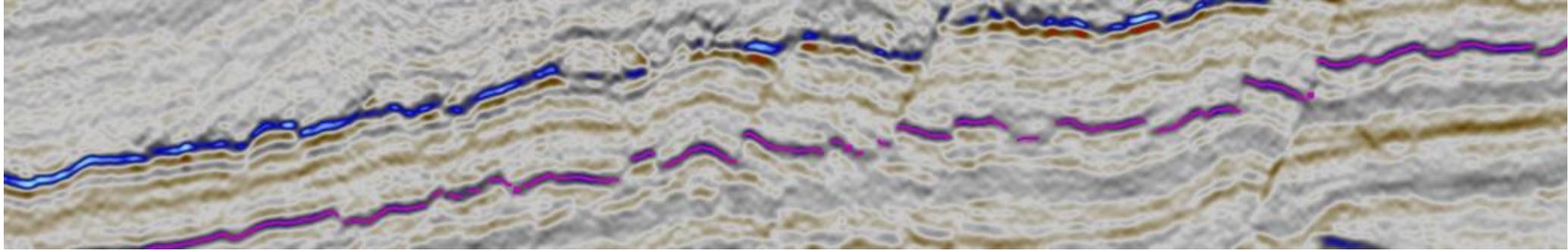
HorizonNet



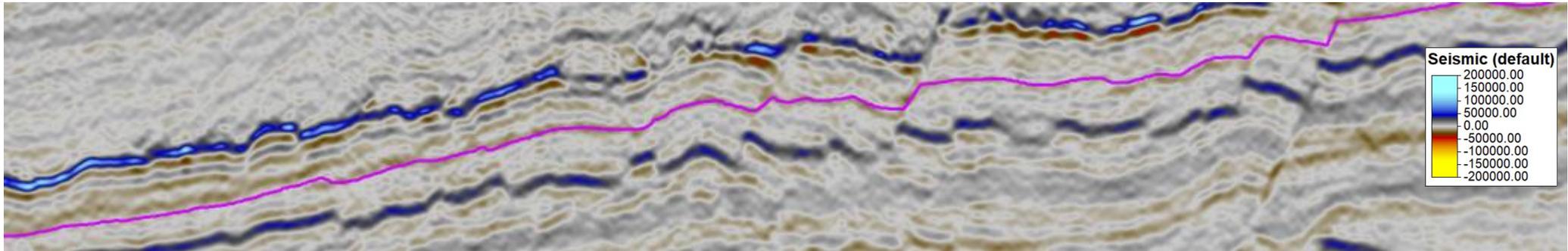
Autotracker

Base Kyrre – HorizonNet vs Autotracker

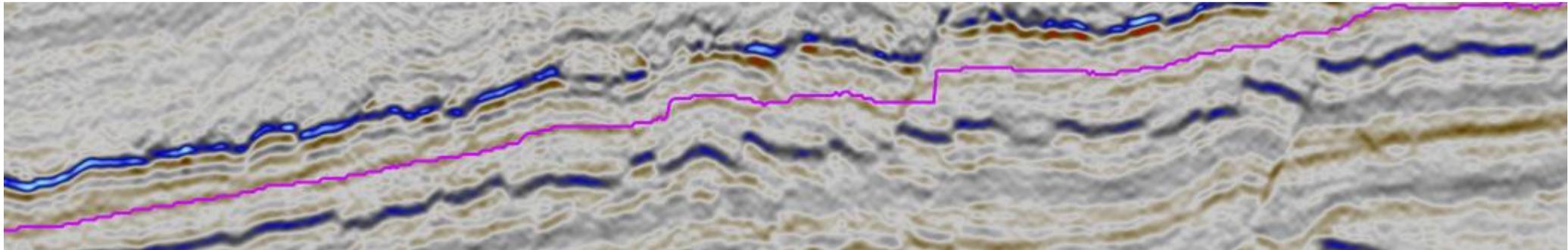
Autotracker



Labelled truth

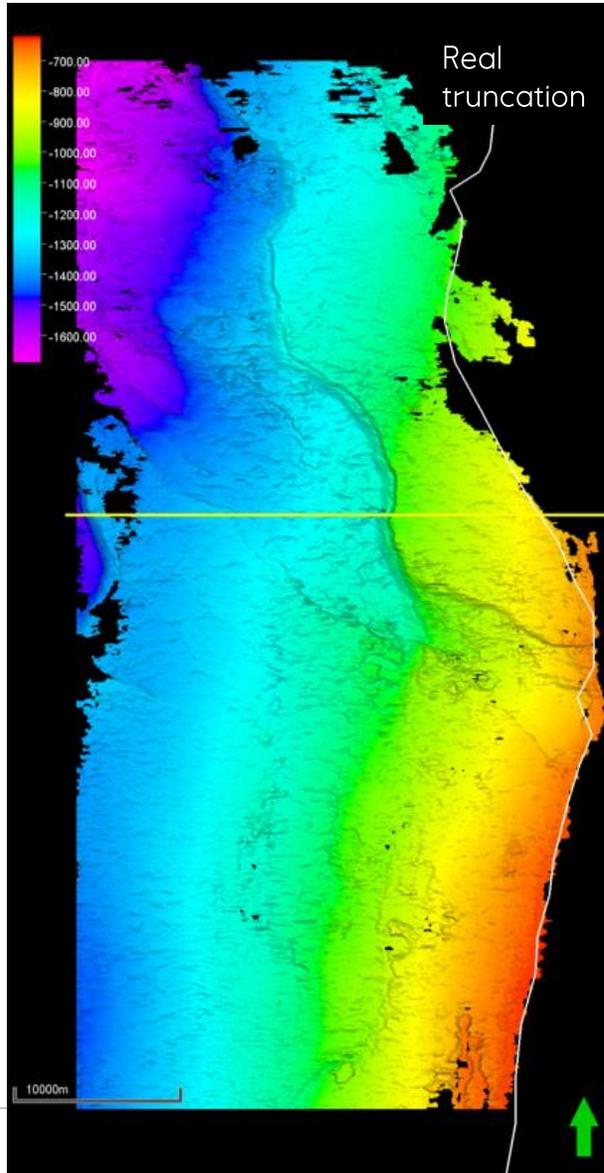


HorizonNet

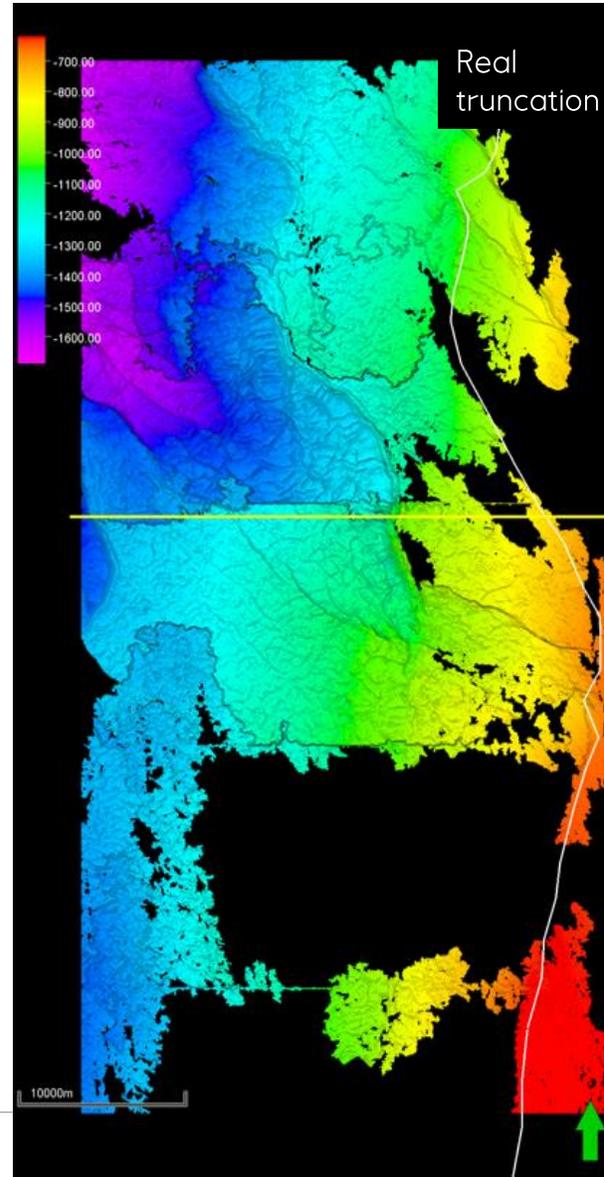


Base Kyrre – HorizonNet vs Autotracker

HorizonNet

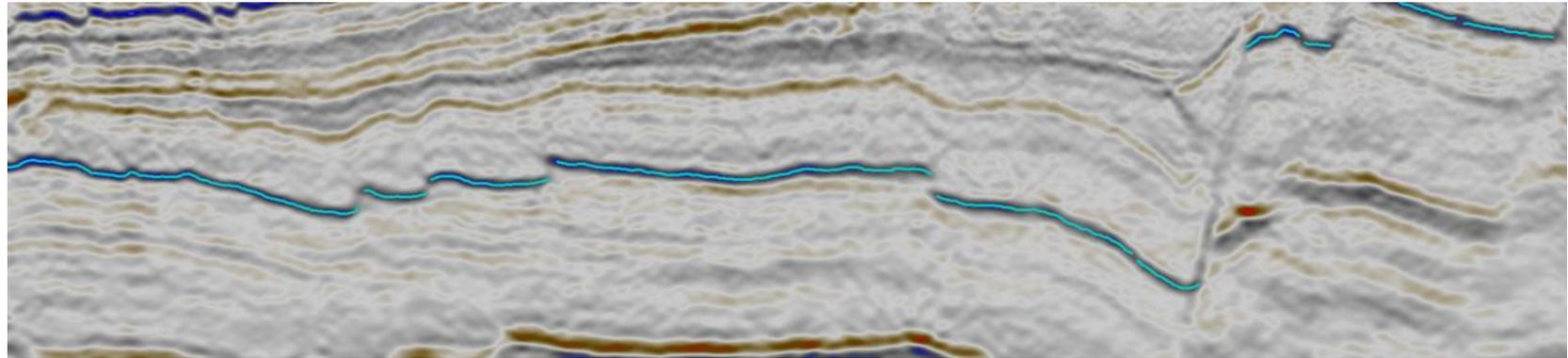


Autotracker

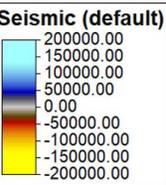
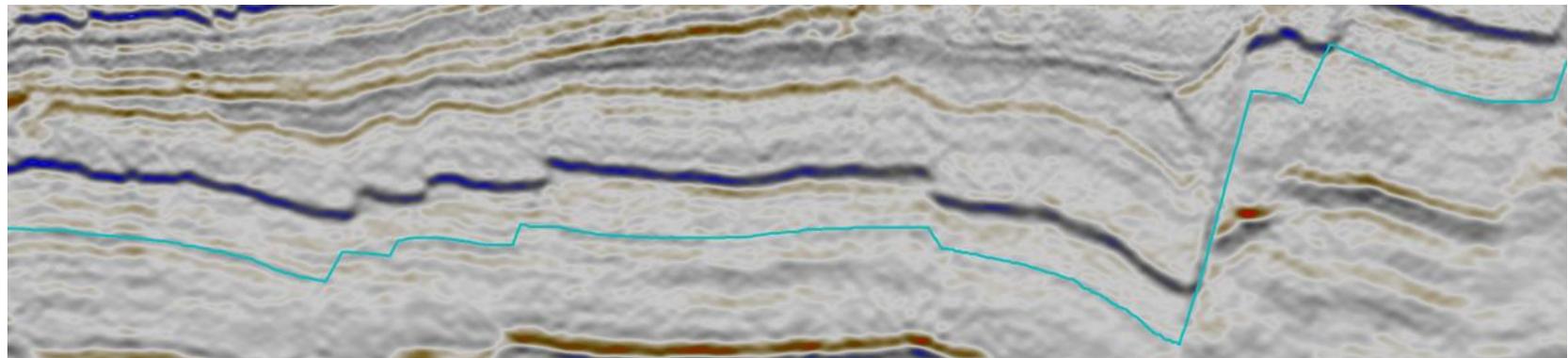


Top Callovian – HorizonNet vs Autotracker

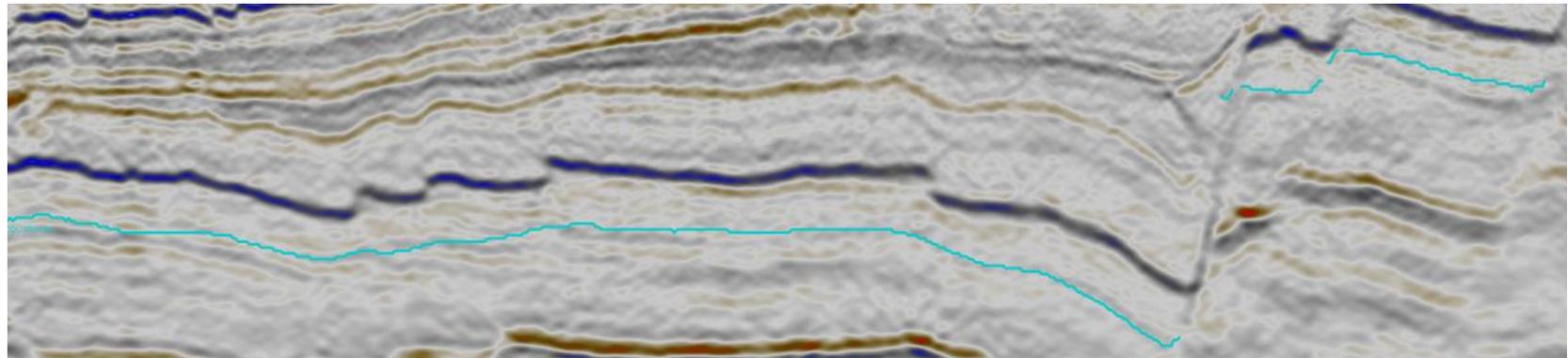
Autotracker



Labelled truth

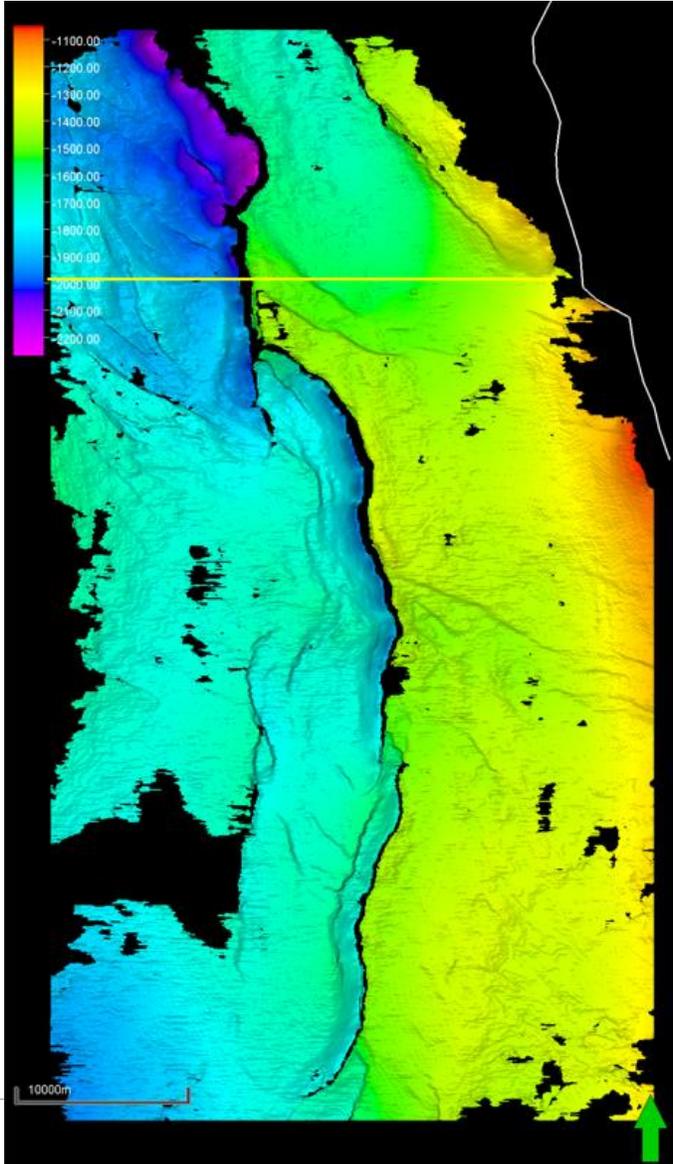


HorizonNet

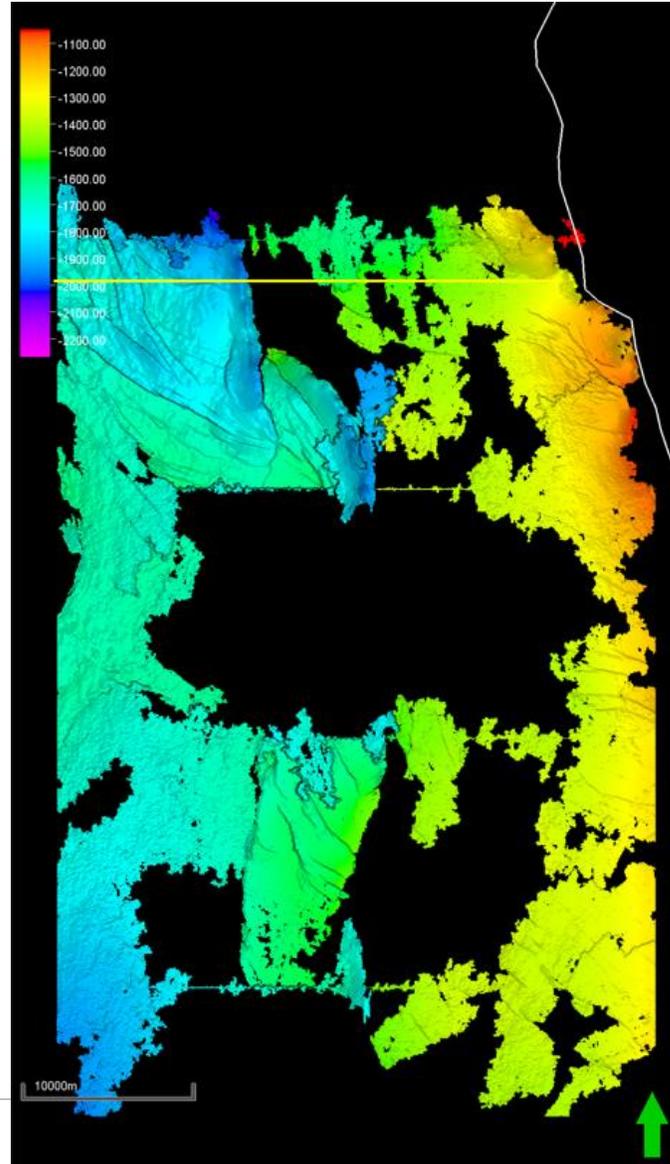


Top Callovian – HorizonNet vs Autotracker

HorizonNet



Autotracker



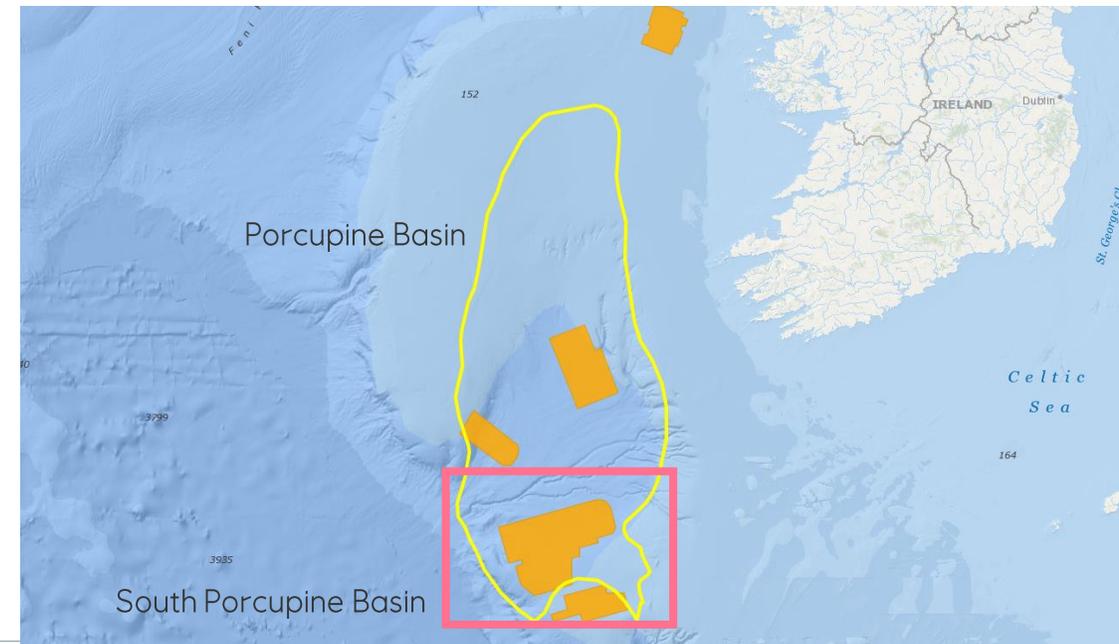
Experiment #1 - Conclusions

- HorizonNet never failed in the test (F1-score: 80-100%)
- Autotracker failed on Top Balder, Base Kyrre, Top Callovian (F1-score: 20-50%)
- Autotracker struggled with right pick on Base Drake and Top Balder due to polarity change - HorizonNet able to cope with this

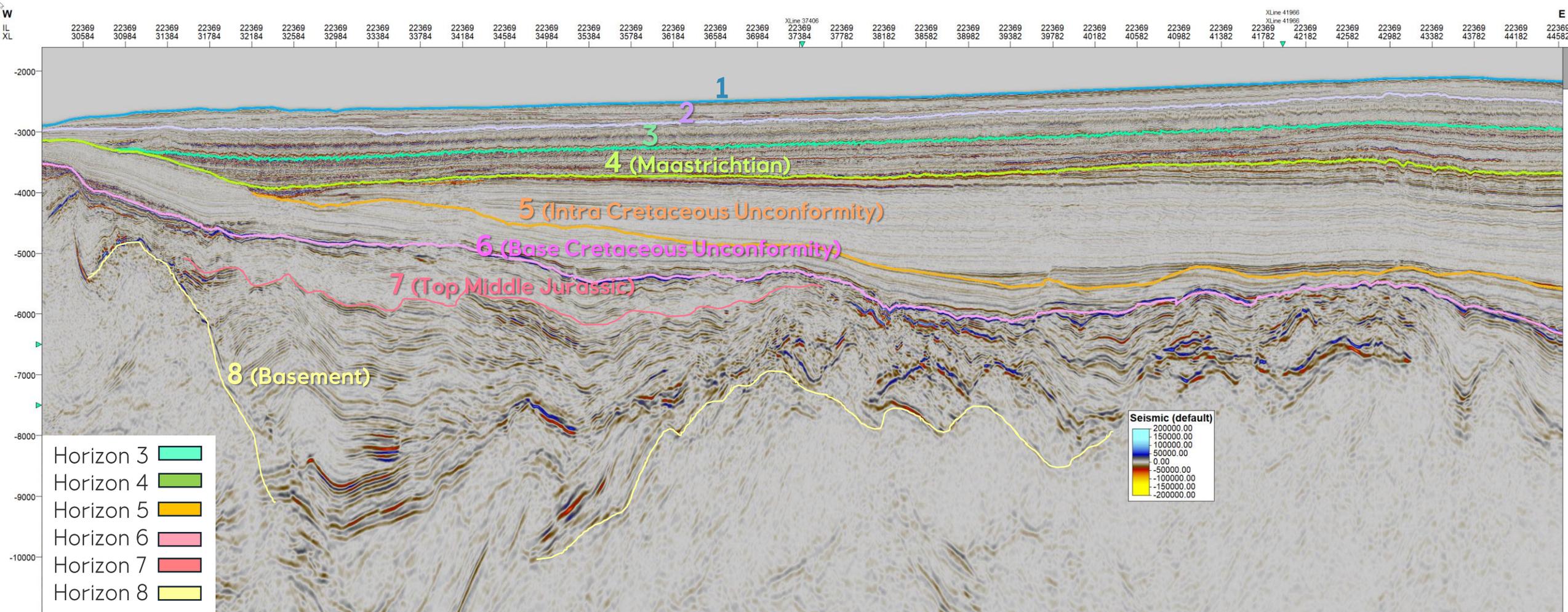
To good to be true?

Experiment #2

- 3D CGG Survey Ireland Offshore of approx. size 3300 km²
- A few lines used to train pretrained network
- Same lines input to autotracker for comparison
- Autotracker set conservative - run with 2 iterations
- 8 key horizons interpreted



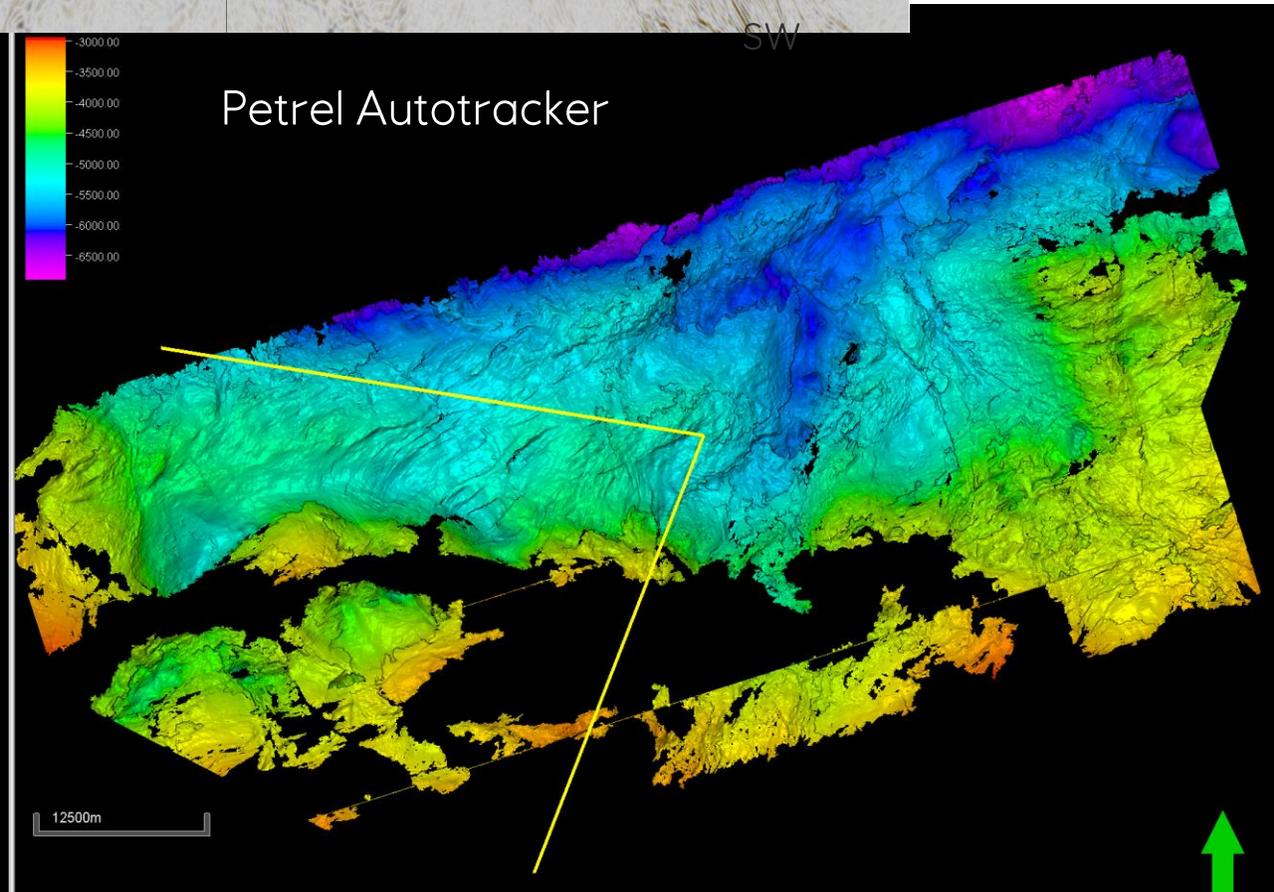
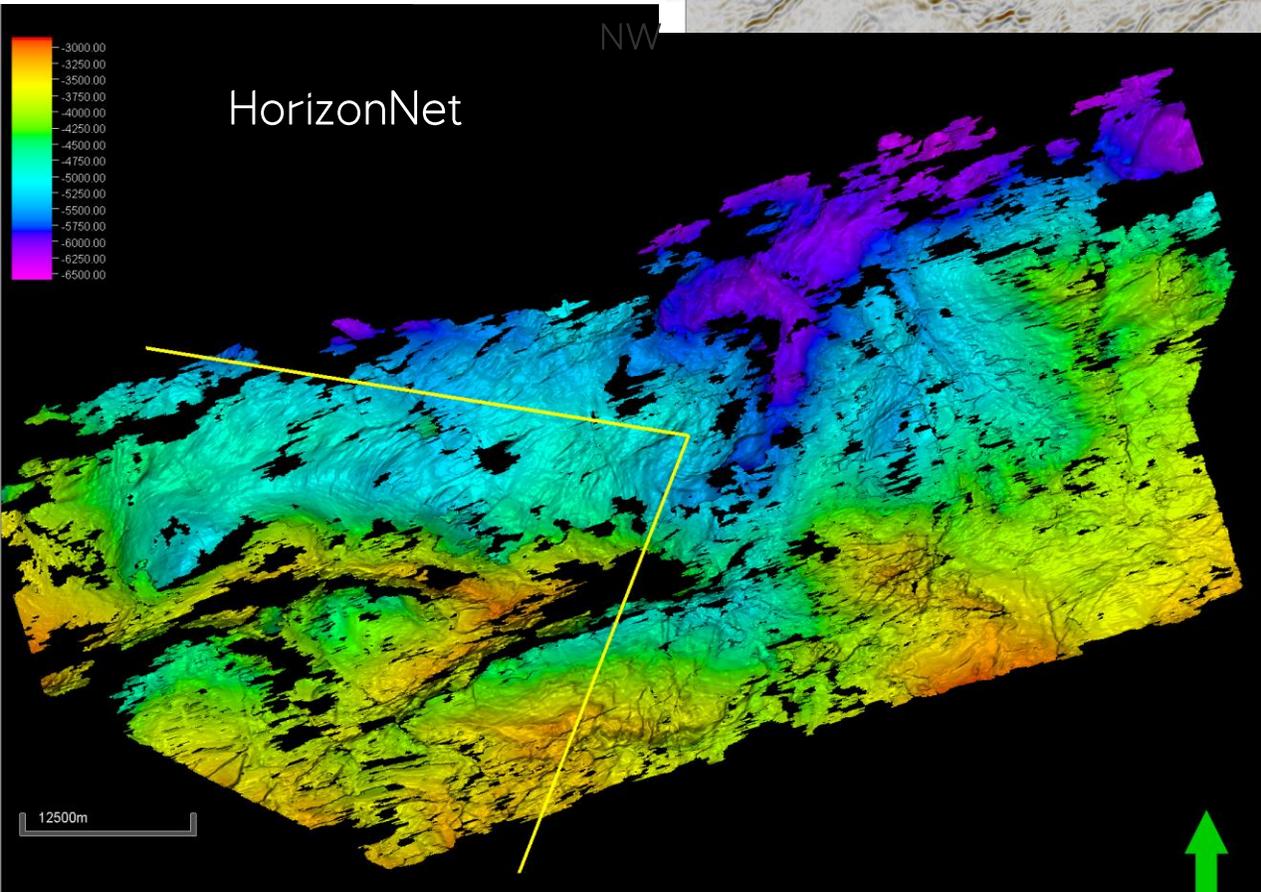
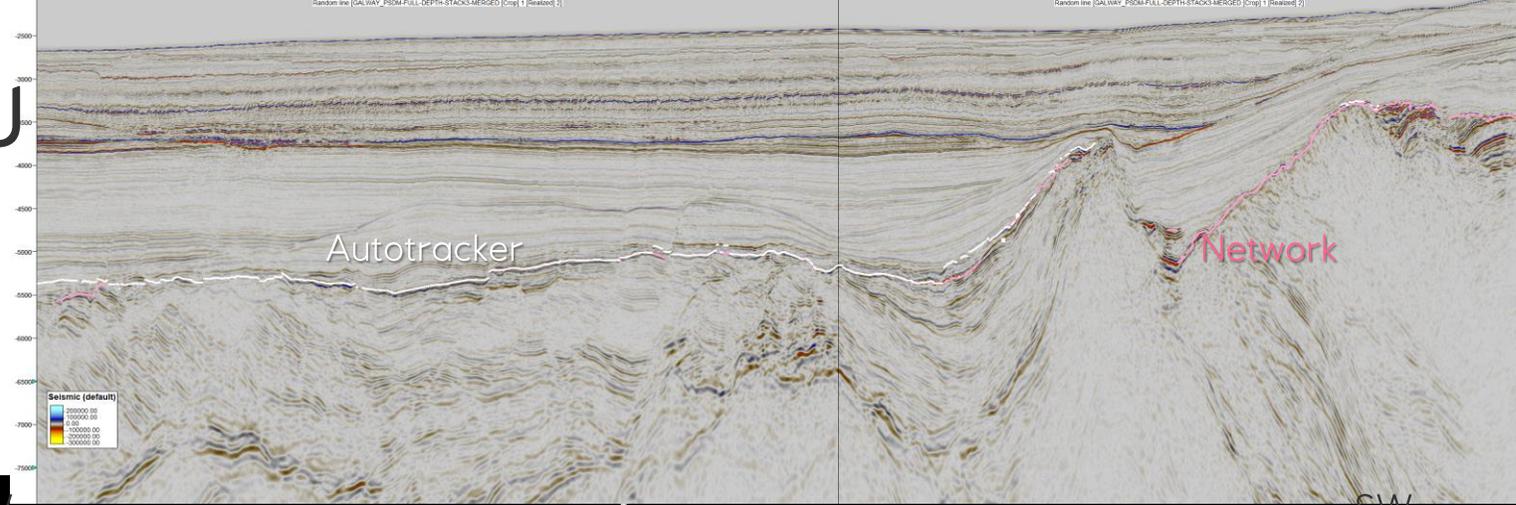
Picked Horizons



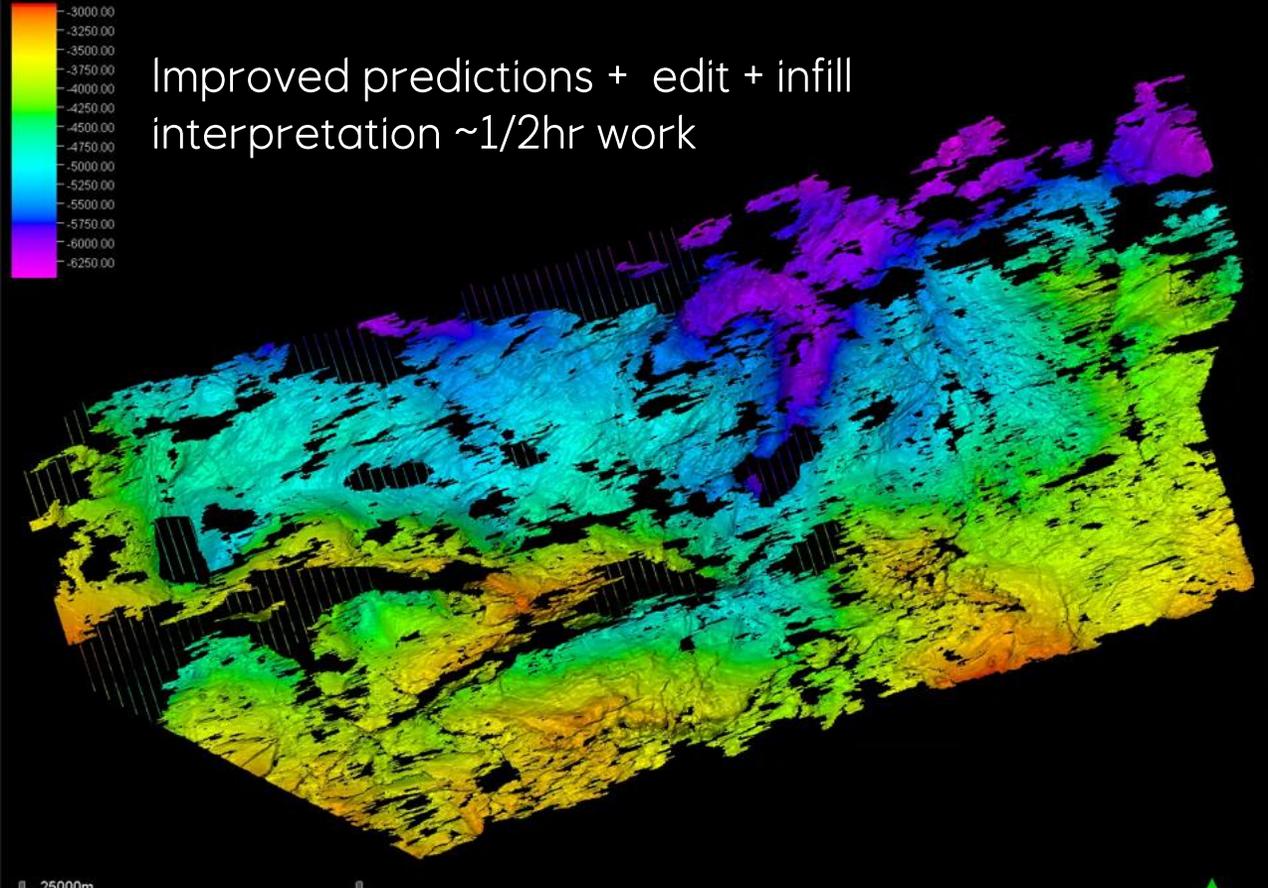
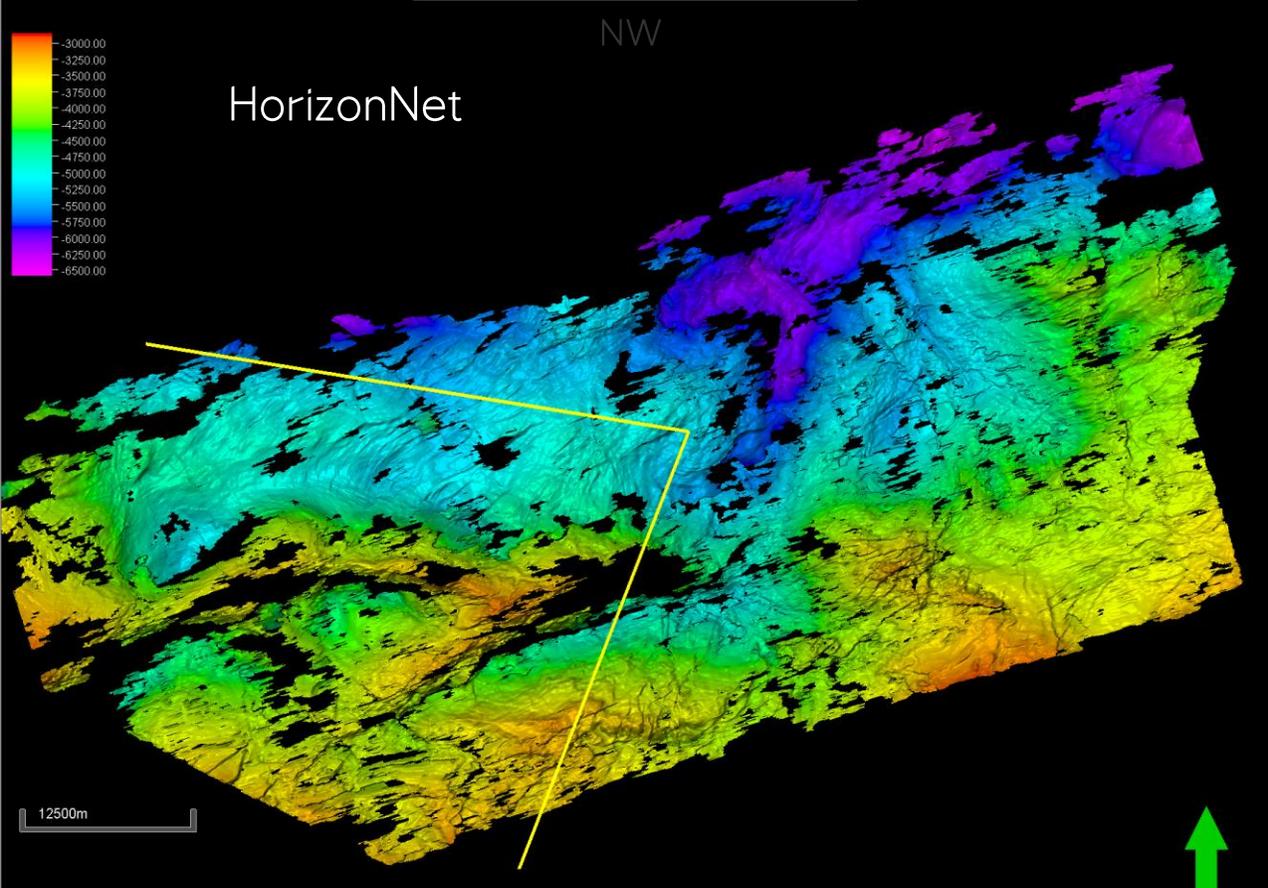
Courtesy of CGG

Horizon 6 - BCU

The HorizonNet picks BCU much better than Autotracker, especially in southern part where the seismic expression changes



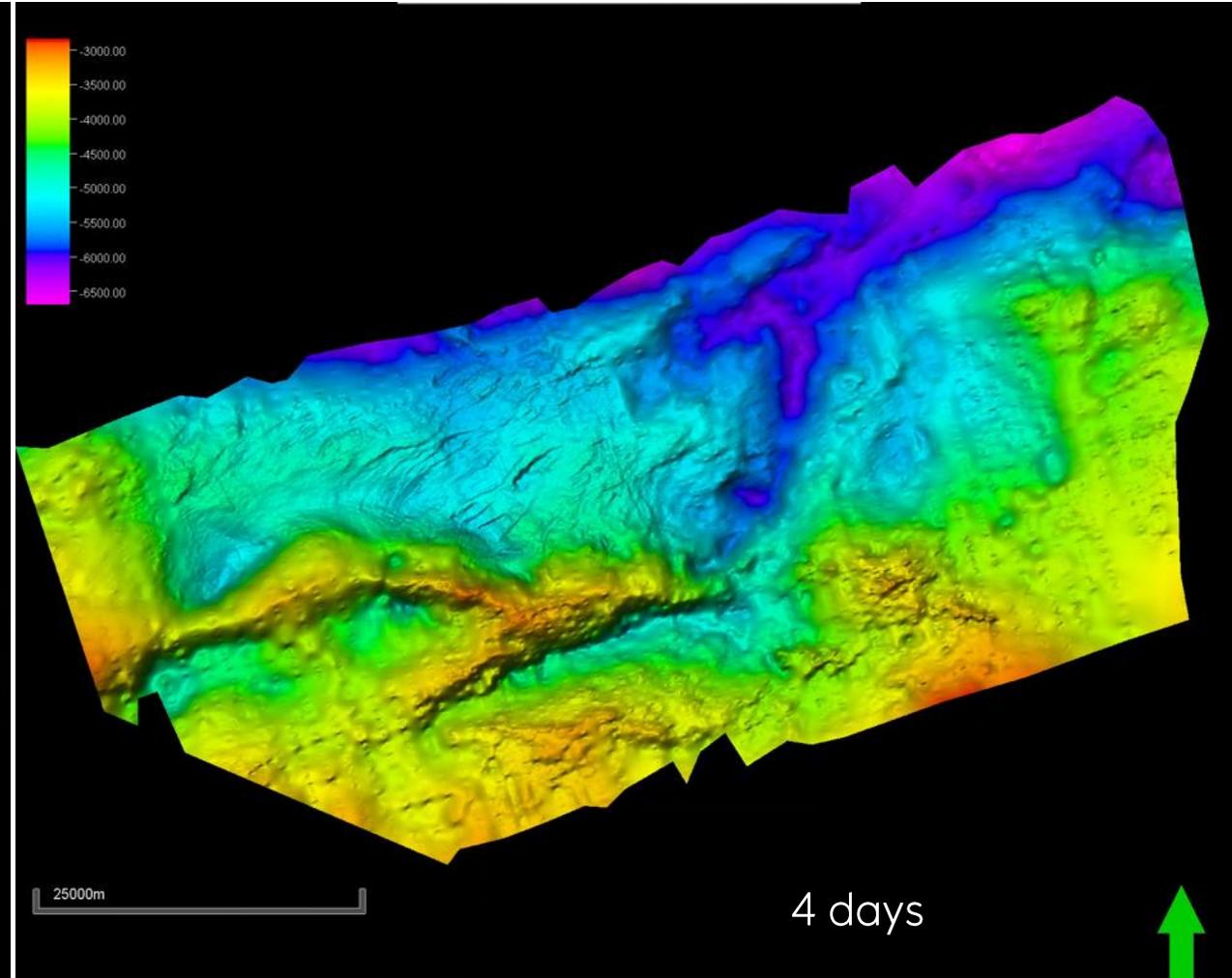
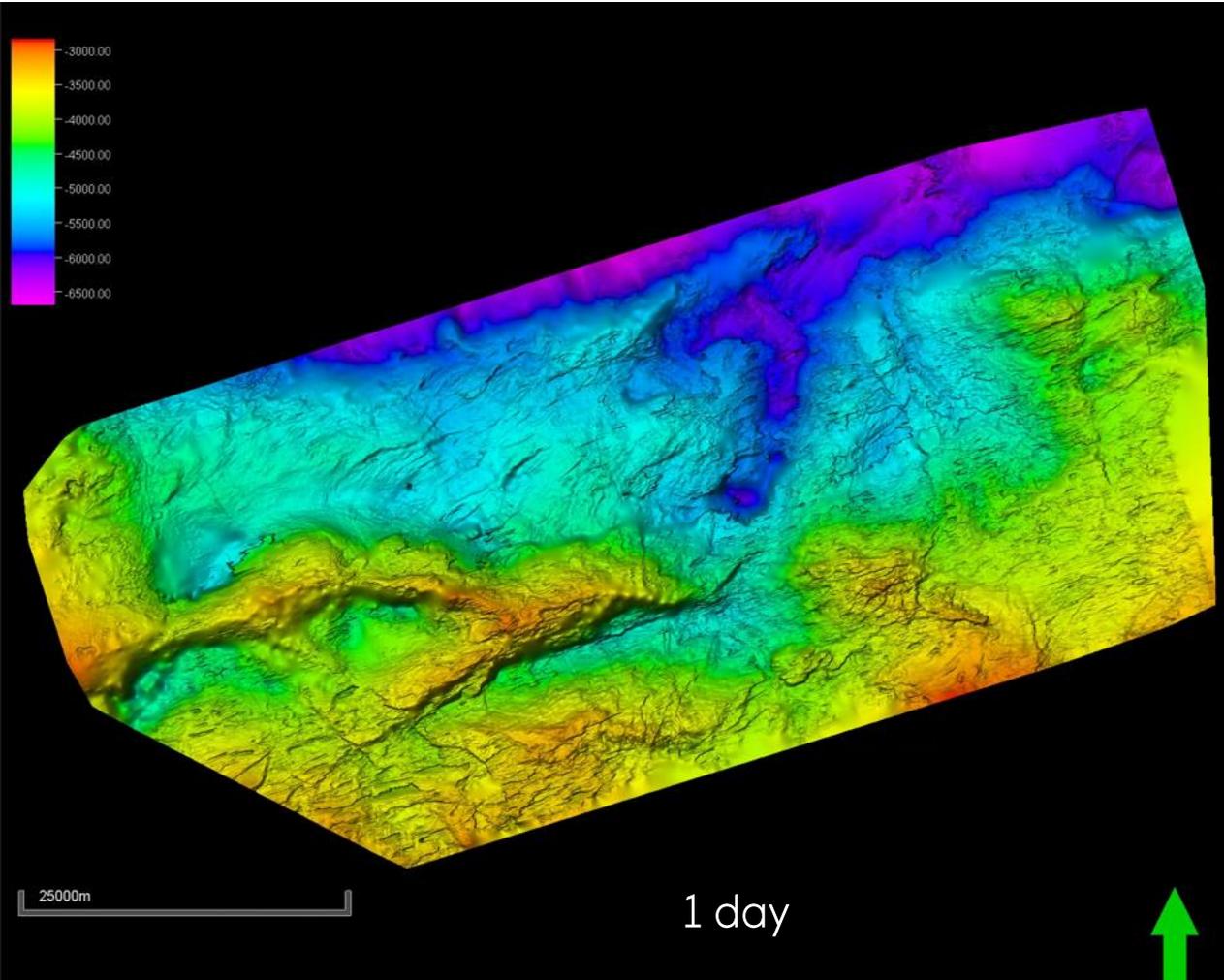
Horizon 6 - BCU



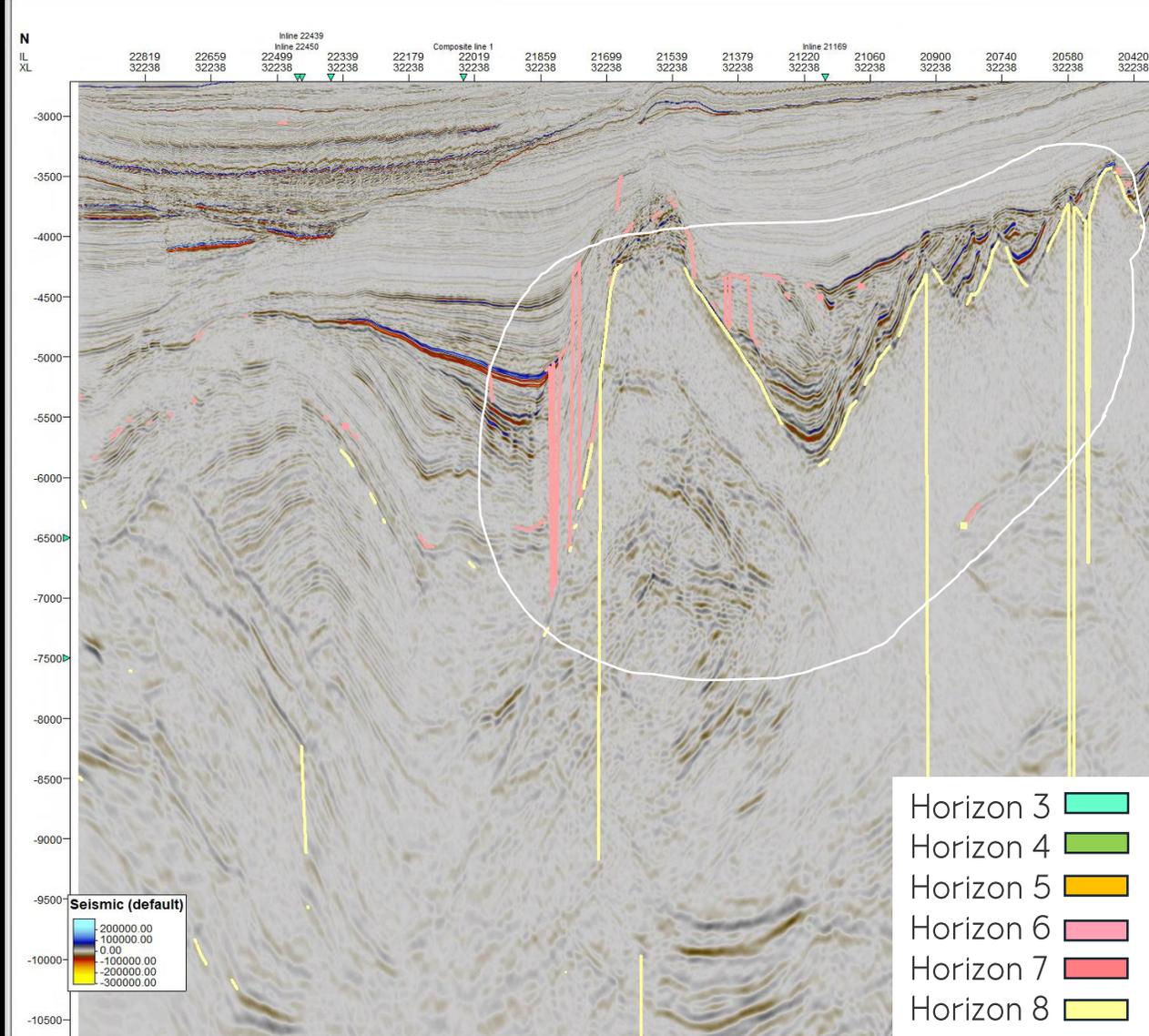
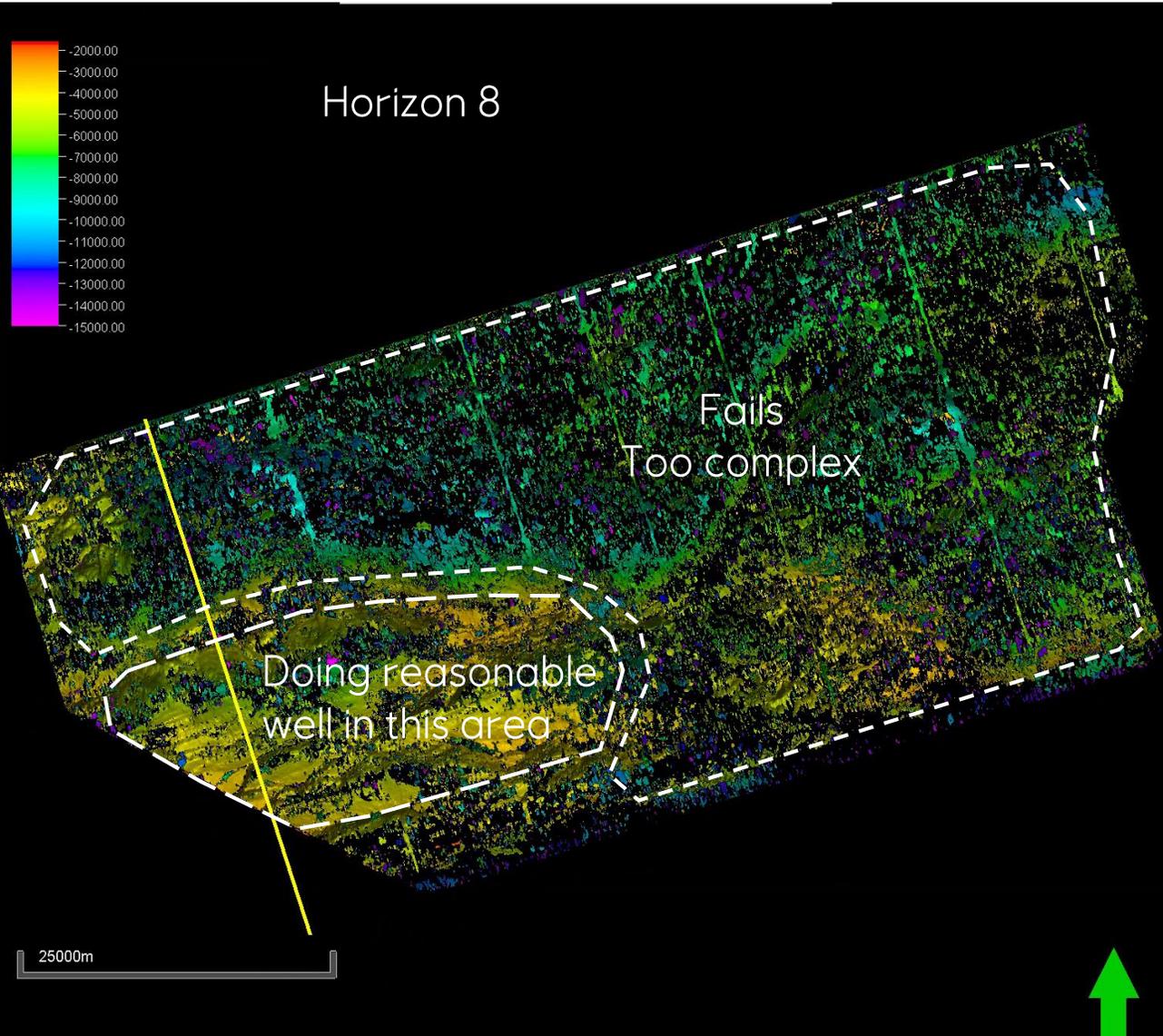
Horizon 6 - BCU

Grid based on HorizonNet + small editing + infill interpretation

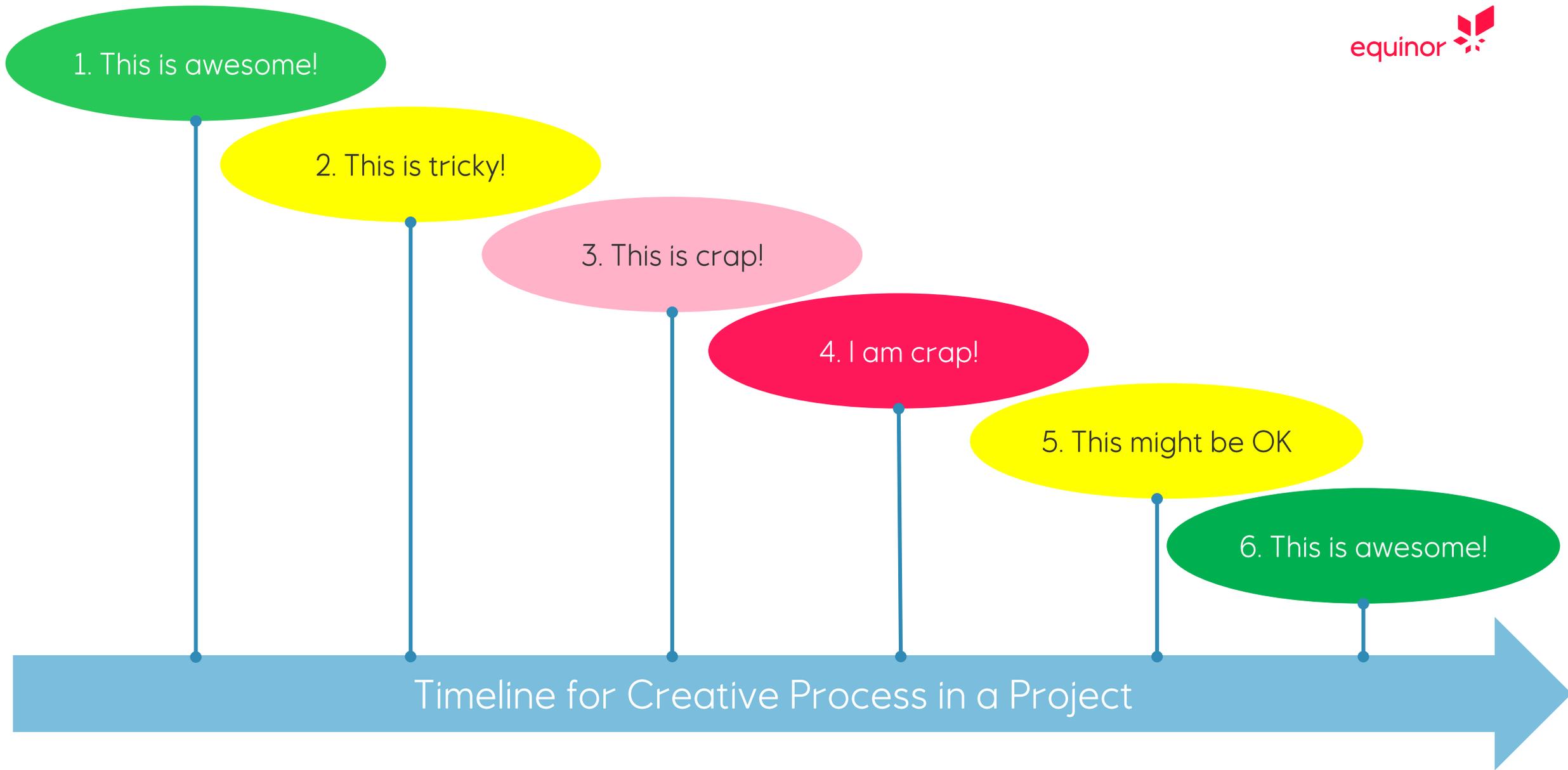
Grid based on manual interpretation



Horizon 8 - Basement



Courtesy of CGG



Ref. [TED-talk](#) Adam Grant
"The surprising habits of original thinkers"

Questions we have answered?

- **Trained DL networks are able to perform quality seismic horizon interpretation**
- The CNN HorizonNet based on U-Net, shows the best results
- This DL network performs better than automatic interpretation when horizons become subtle, discontinuous or contains a polarity shift

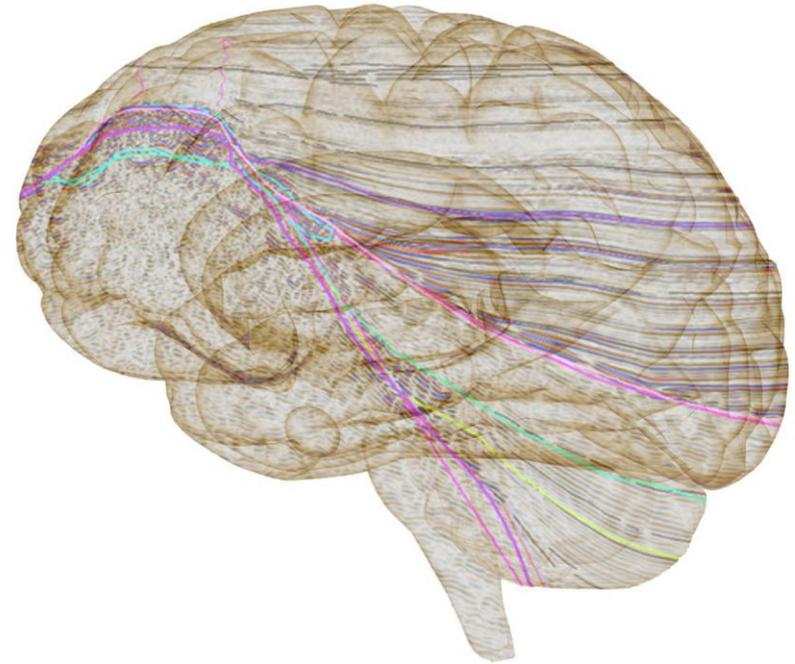
HorizonNet Deep Learning Interpretation



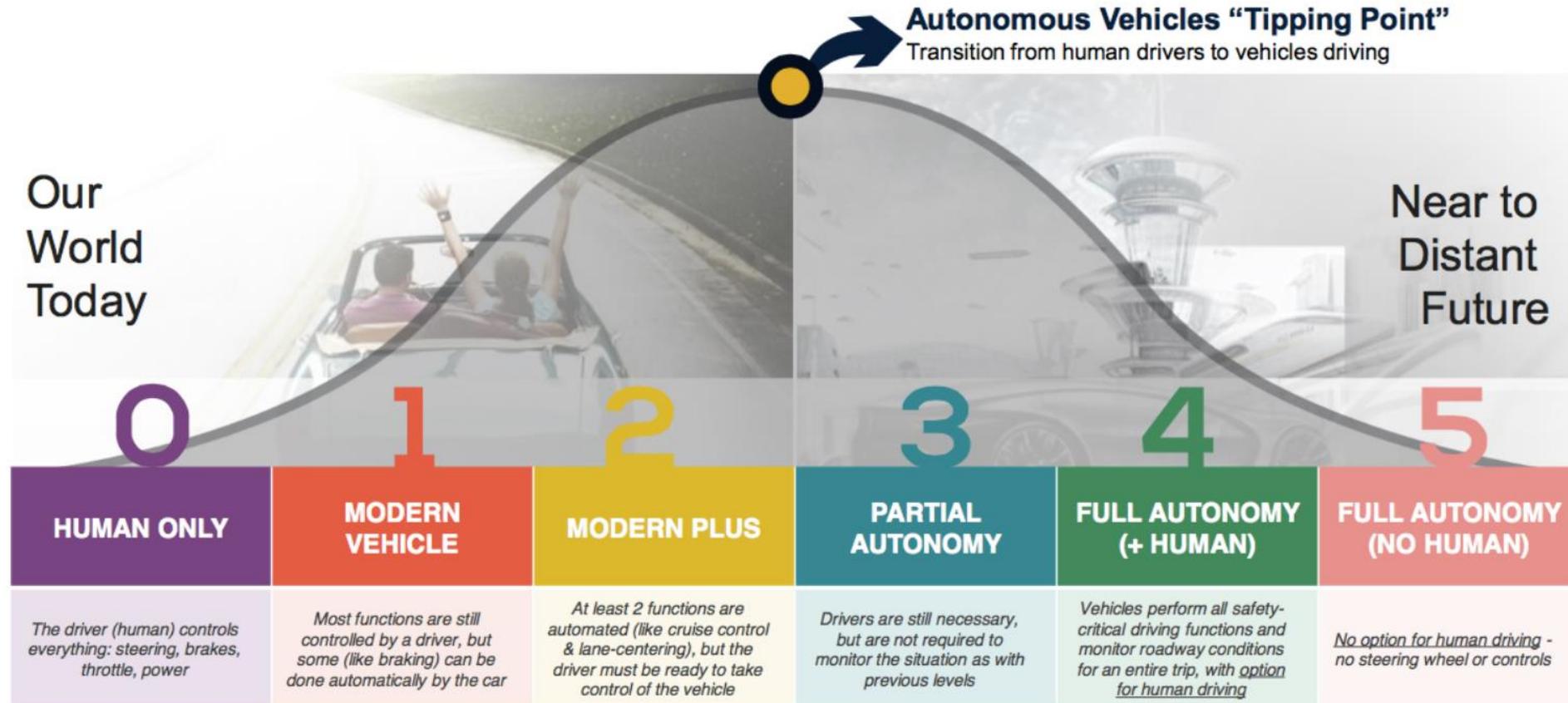
Autotracker often fails
Manual work time consuming

Future work...

- Verify network in new geographical areas with different geology
- Verify it works on 2D as well as on 3D
- Search for better or improved network models
- Improve the networks efficiency, speed and quality
- Design optimal workflow and integrate with existing interpretation tools and workflow

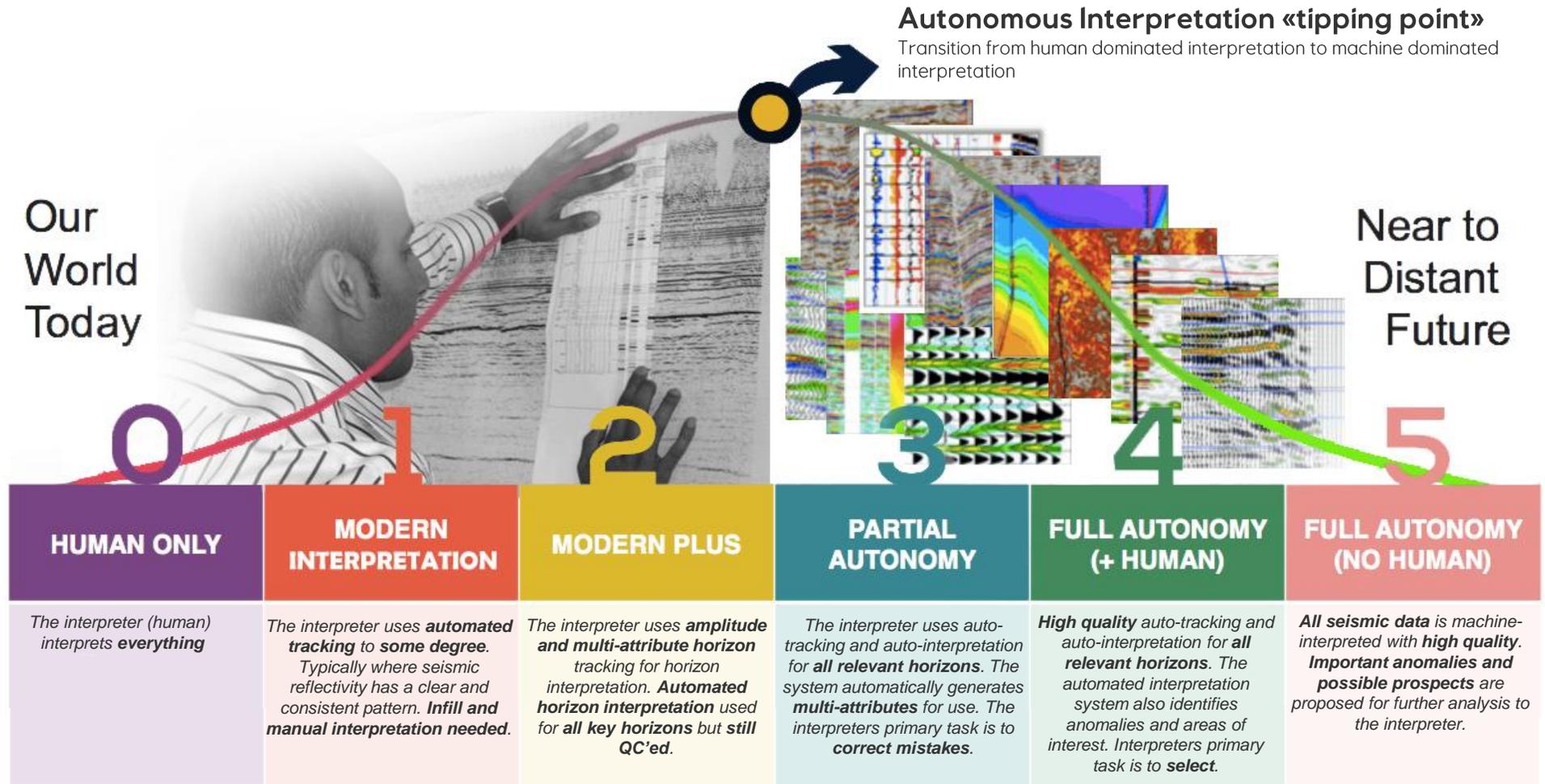


The Levels of Autonomous Vehicles



The Society of Automotive Engineers' levels which was adopted by the National Highway Traffic Safety Administration

The Levels of Seismic Interpretation



Questions?

Deep Learning Neural Network Solution Applied to Seismic Horizon Interpretation

Jens Grimsgaard
R&T ET PSM

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