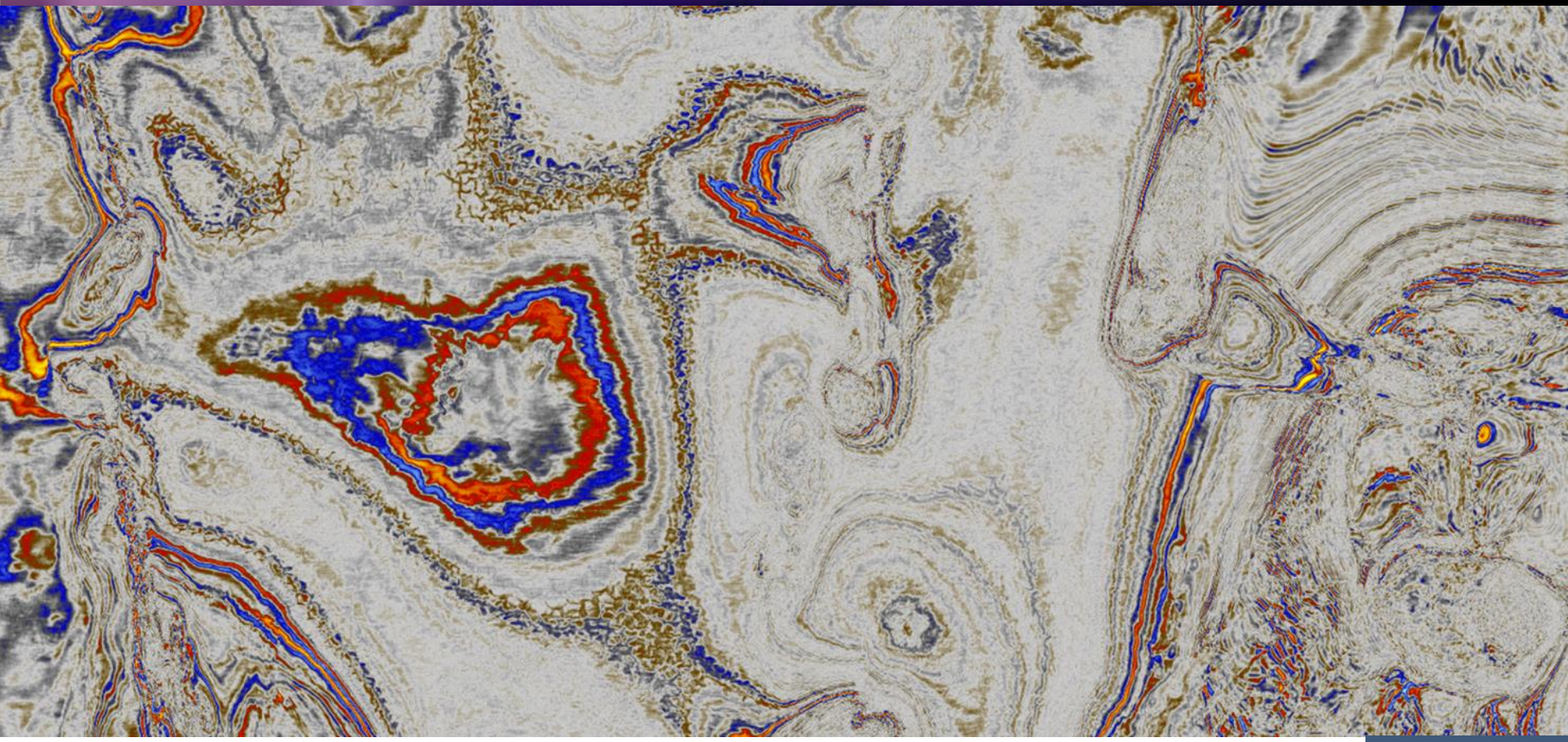
Observations from systematic depth conversion reviews: biased depth estimates and the impact on the drilling portfolio



VIENNA 2016

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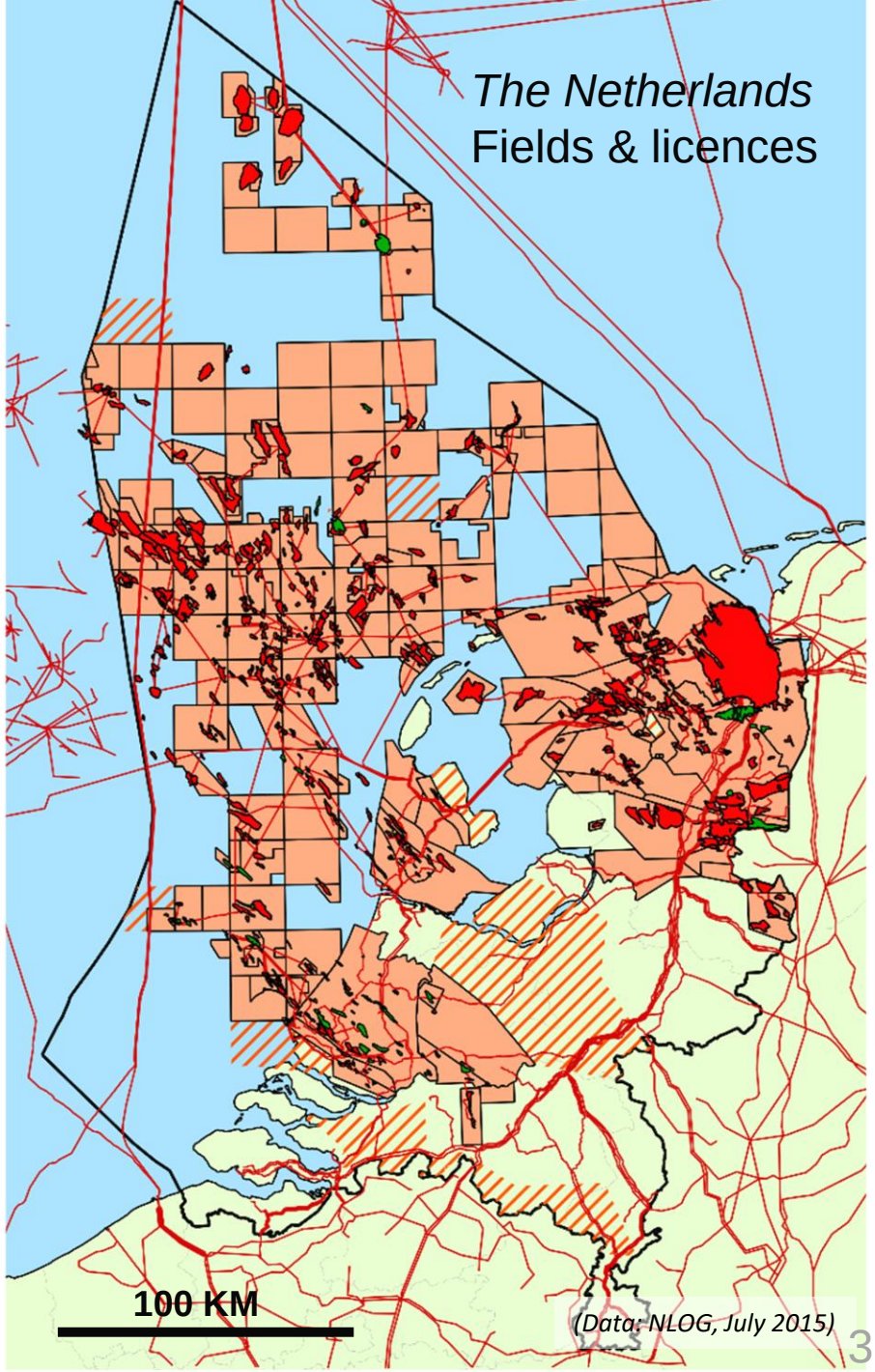
ebn

contents

- Background
- Depthing matters
- Typical depth conversion workflow
- Depth errors & bias
- Explaining the bias
- Conclusions

About EBN

- **EBN invests in exploration and production of natural gas and oil on behalf of the Dutch State**
- **Number of employees: 81 (2016)**
- **Participates in nearly all dutch upstream (~40% share)**
- **Production: ~500k boe/d (2014)**
- **All profits of EBN are transferred to Dutch government: € 4.9 bln (2014)**
- **Access to most data**



About EBN

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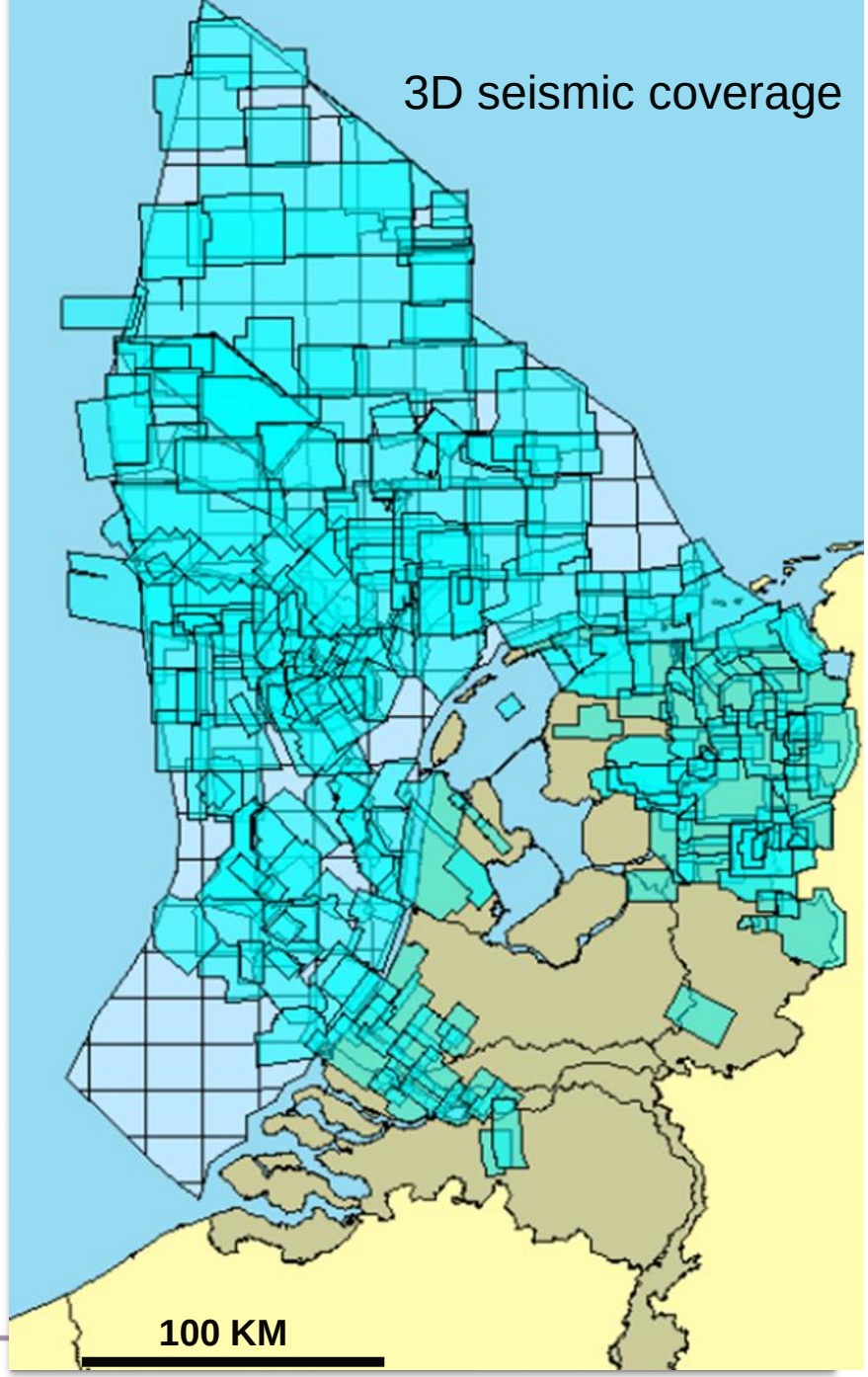
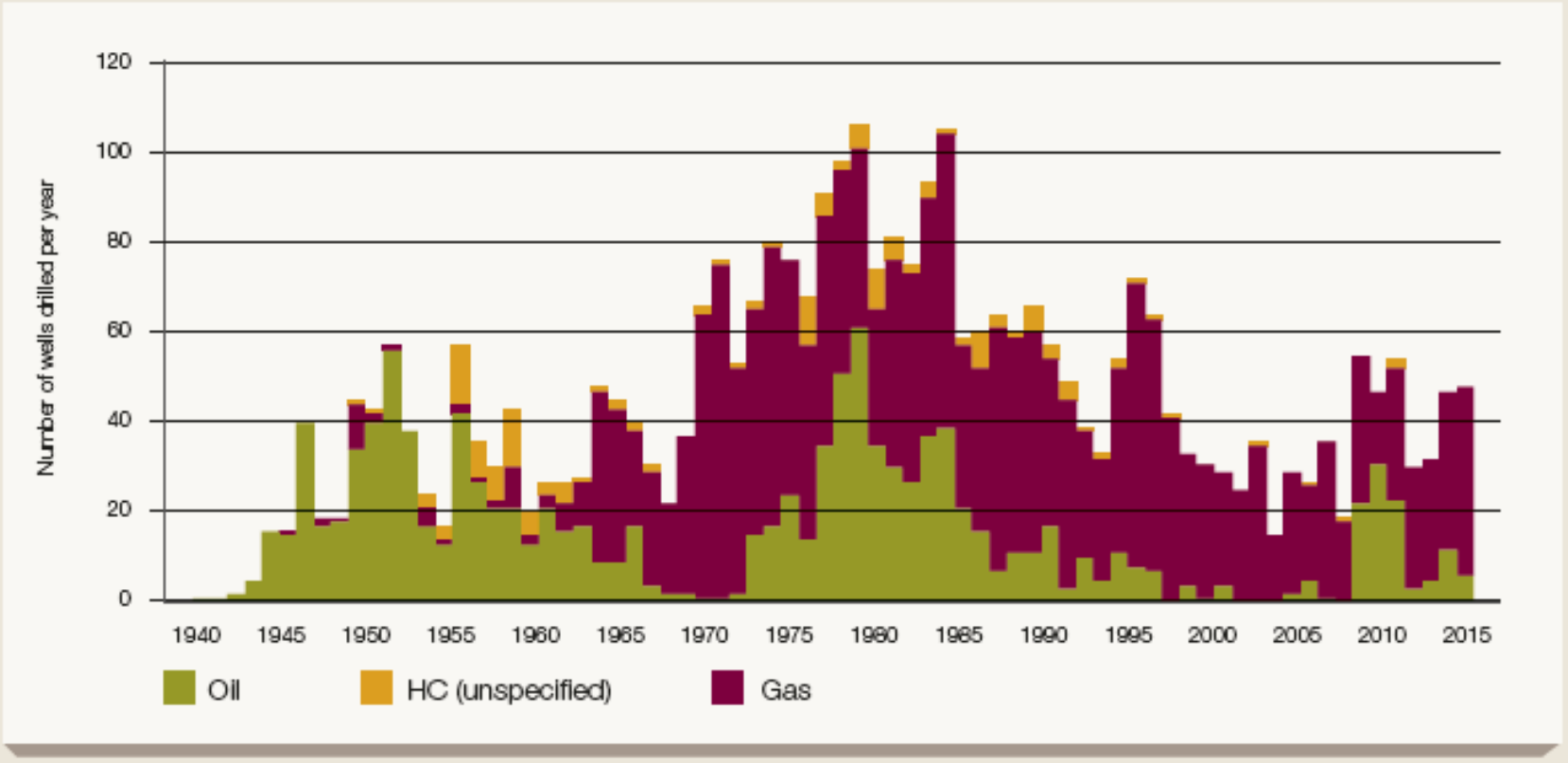
- **140,000 km2 3D seismic**
- **> 5,000 wells**



~40 new wells annually

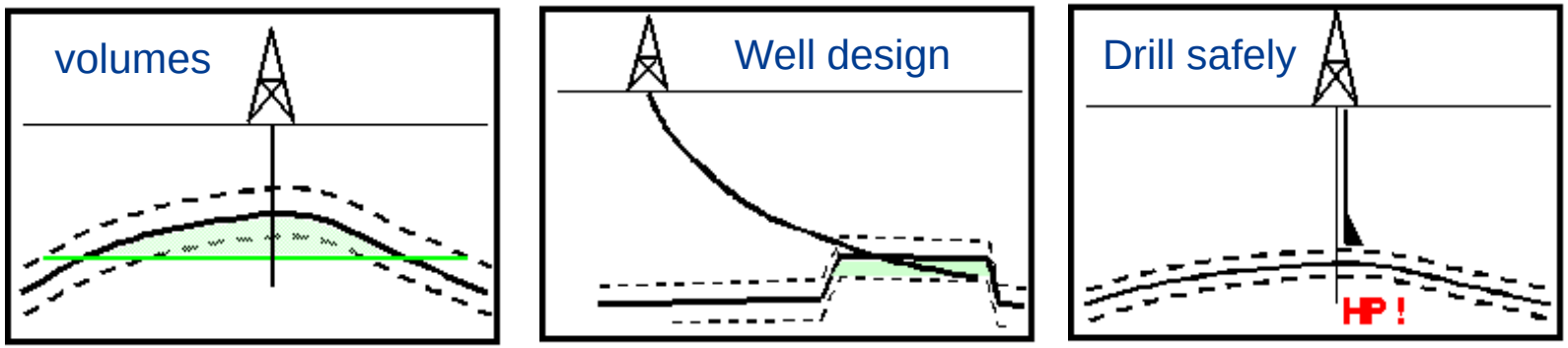
do test seismic technology in NL



Depthing matters…

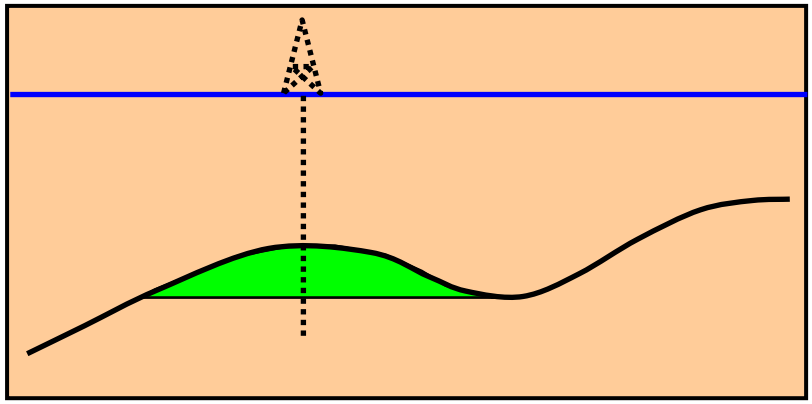
More accurate description of subsurface allows better project risking/ ranking and execution (*including better & safer wells!*)

Depth prognosis is a key parameter

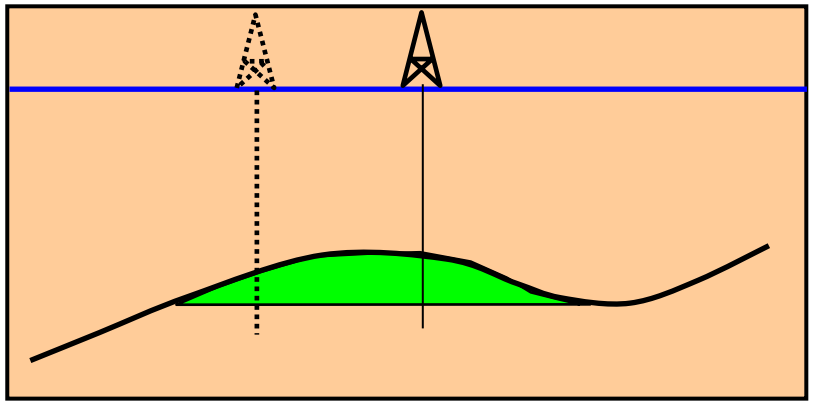


Impact depth conversion: situation dependent

prognosis

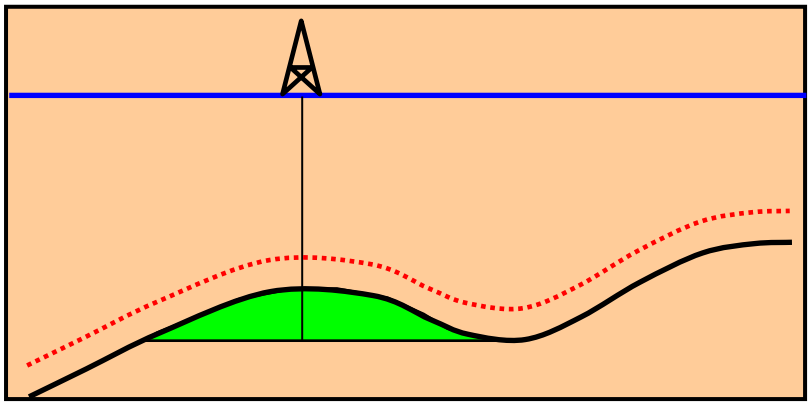


Typical exploration case

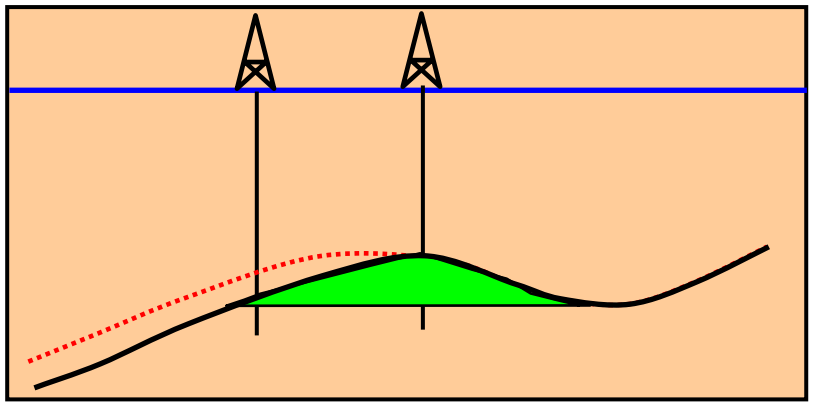


Typical development case

actual



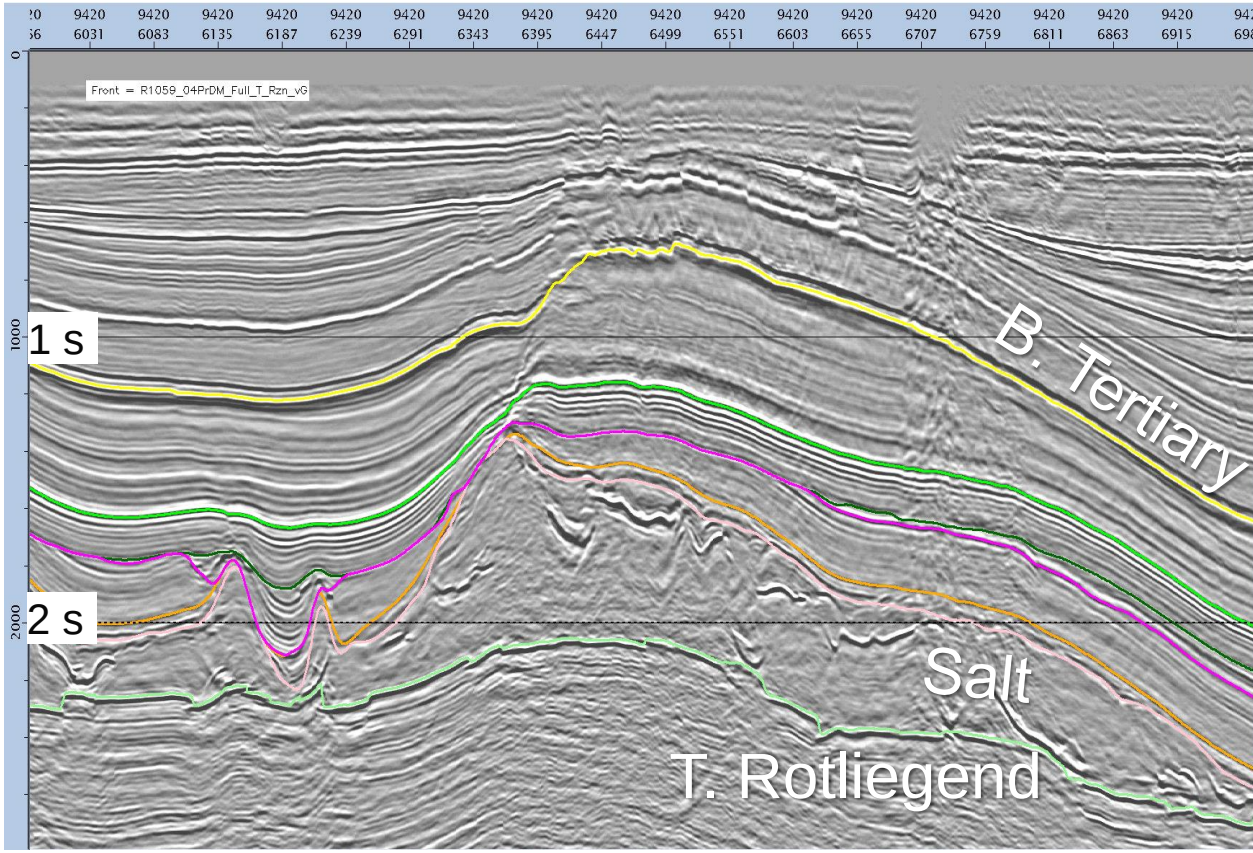
If entire structure deep to prognosis:
closure unaffected & well still successful



If structure locally deep to prognosis and
contact fixed: HC column in well reduced

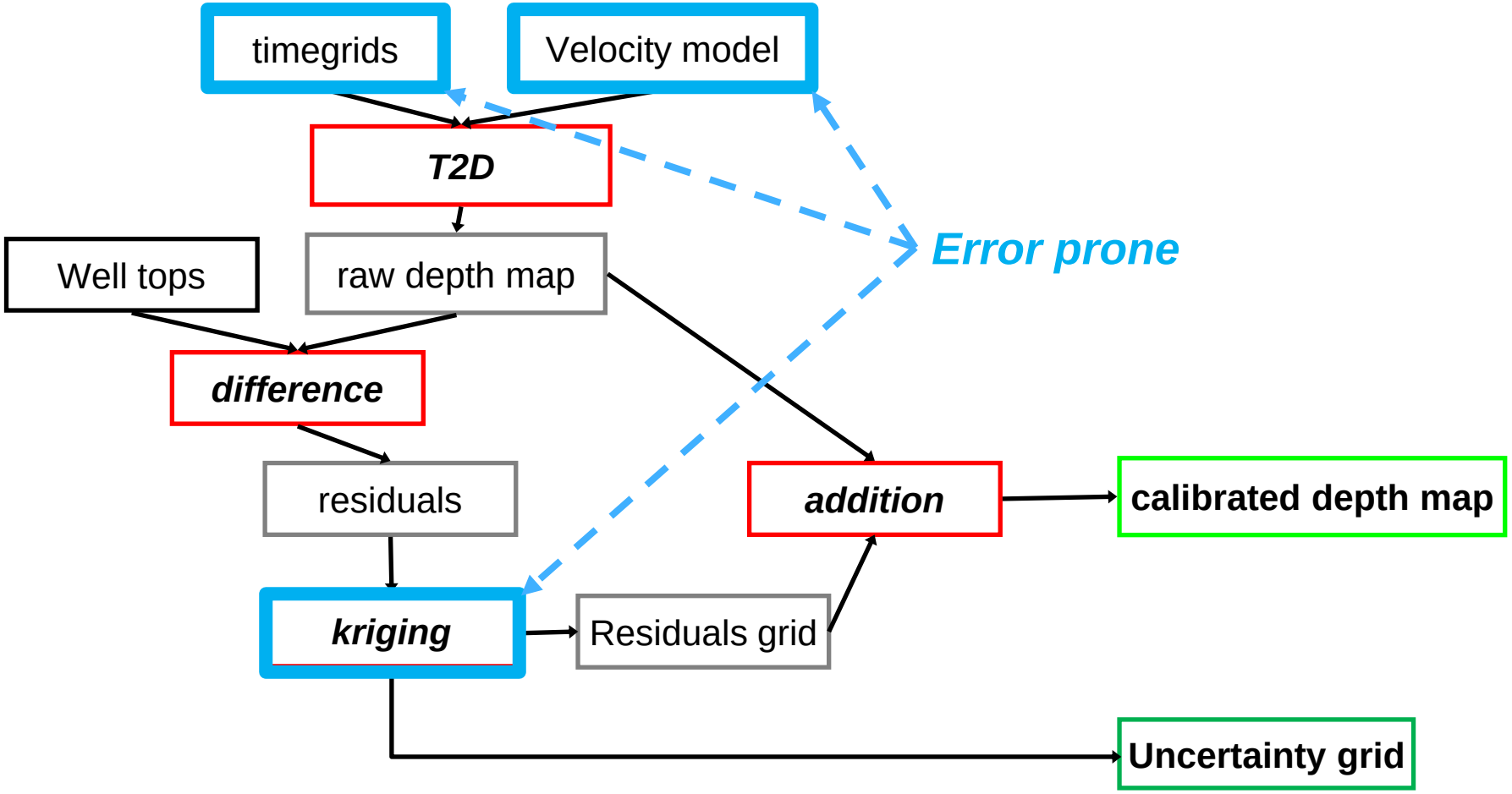
Typical Time-Depth conversion workflow (1)

- 3D PreSDM data
- Interpretation on timedata
- Layercake approach
- Velocity model based on well data and pro-velocities
- Frequent use of V0,K velocity parametrisation (per layer)



pull-up effect

Typical Time-Depth conversion workflow (2)

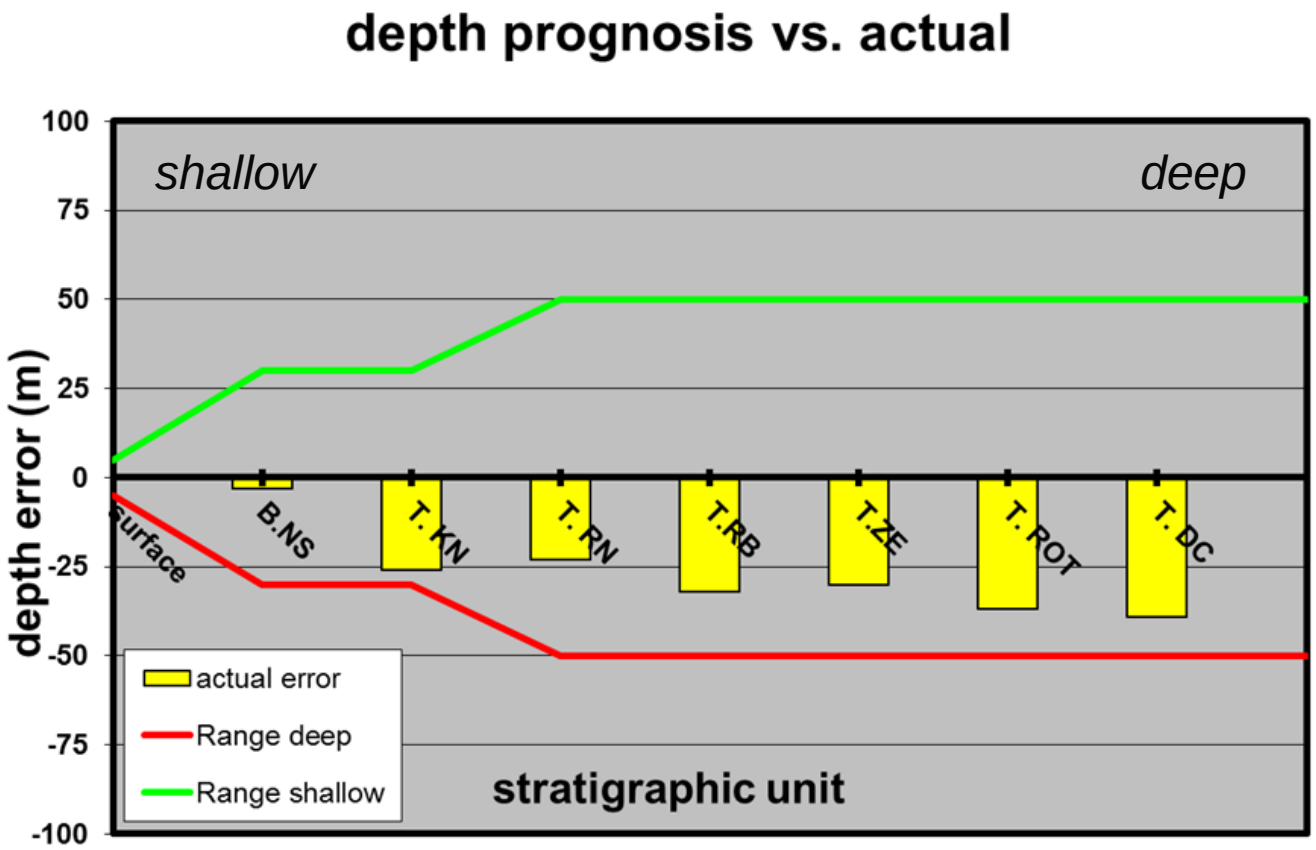


Depth prediction review

- 253 recent wells (all operators)
- Comparing **prognosed** depth vs **actual** depth:

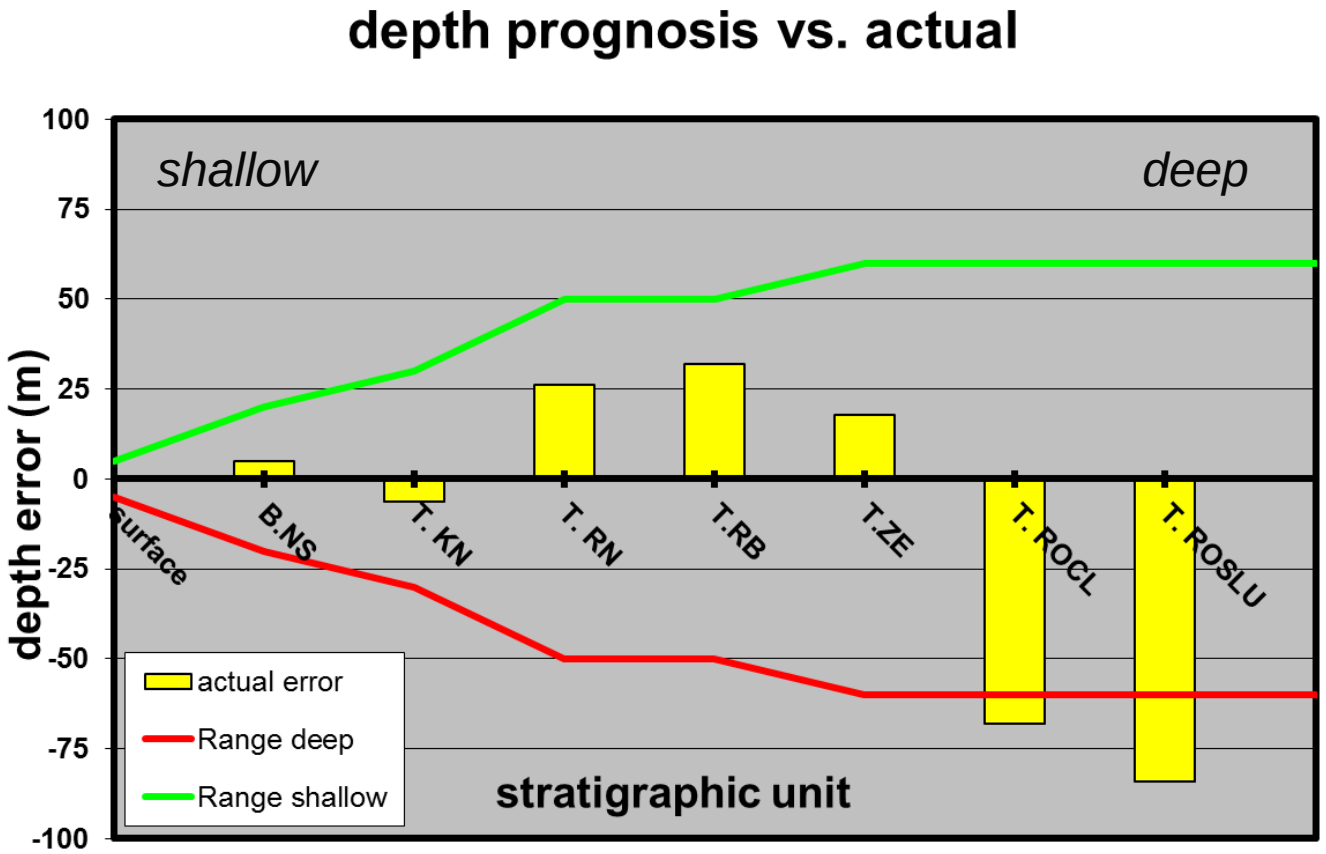
  at target level and overburden levels
- Analyse depth errors

Depth errors: example A



Conclusion: velocity layer 2 underestimated:
error propagates down, but within range

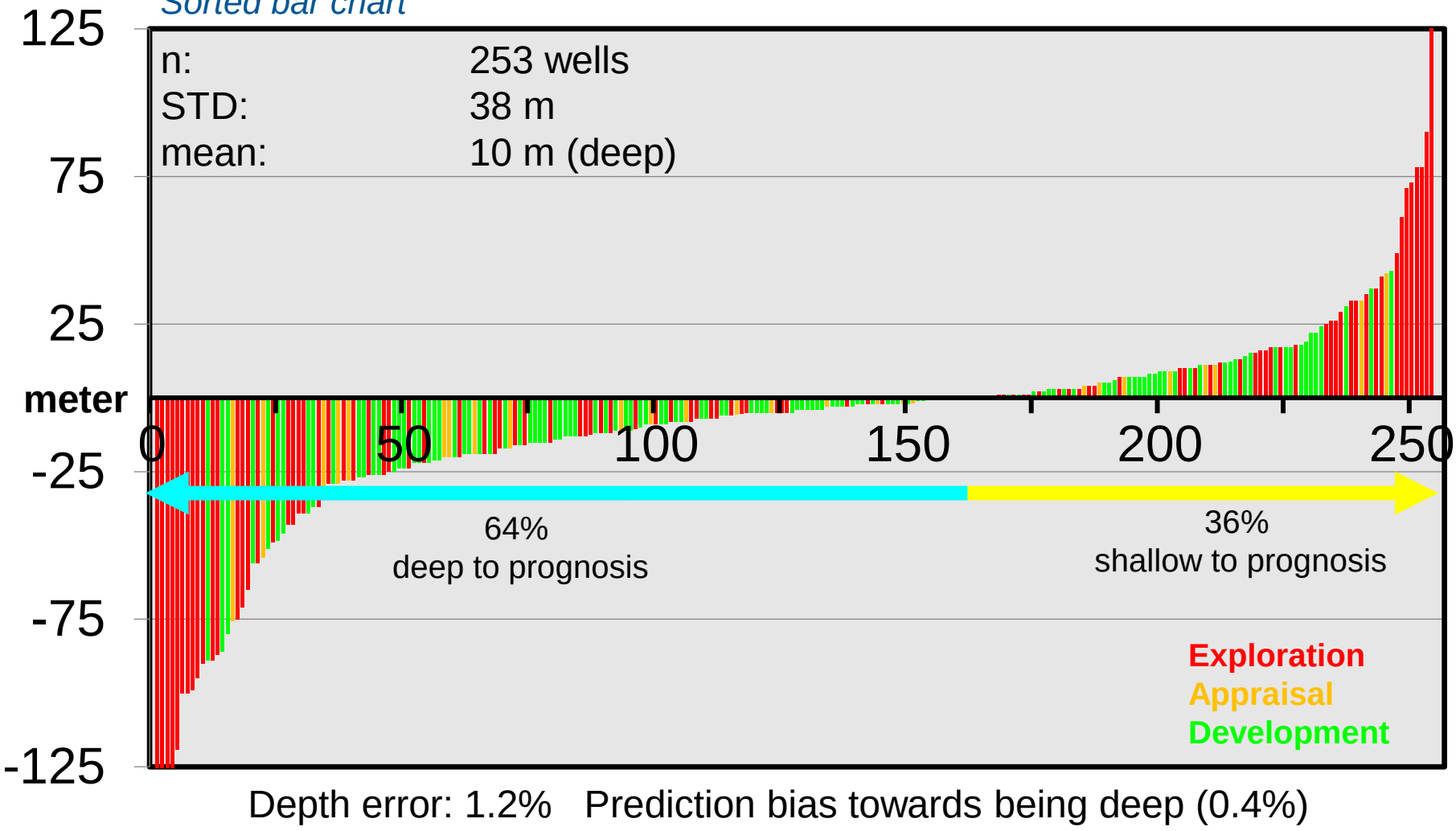
Depth errors: example B



Conclusion: velocity layer 6 (*evaporites*) underestimated: outside range!

Depth errors (target level)

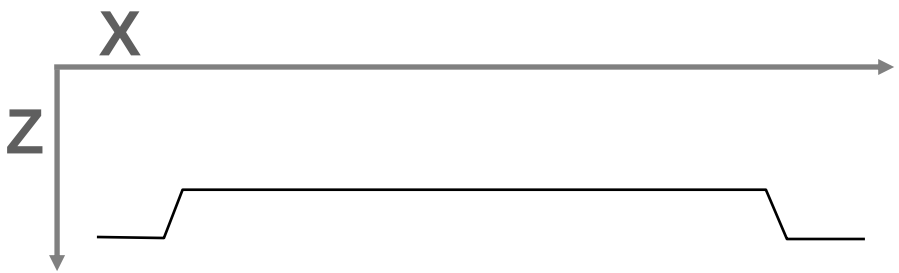
Sorted bar chart



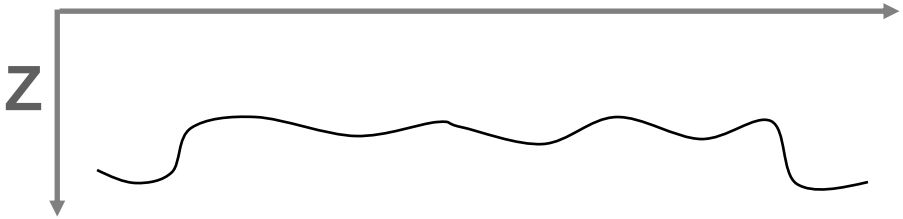
Depth error: 1.2% Prediction bias towards being deep (0.4%)

Why biased estimates?

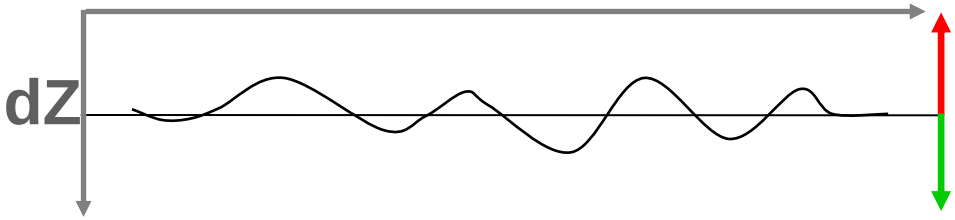
Seismic maps contain noise



real surface



seismically mapped surface



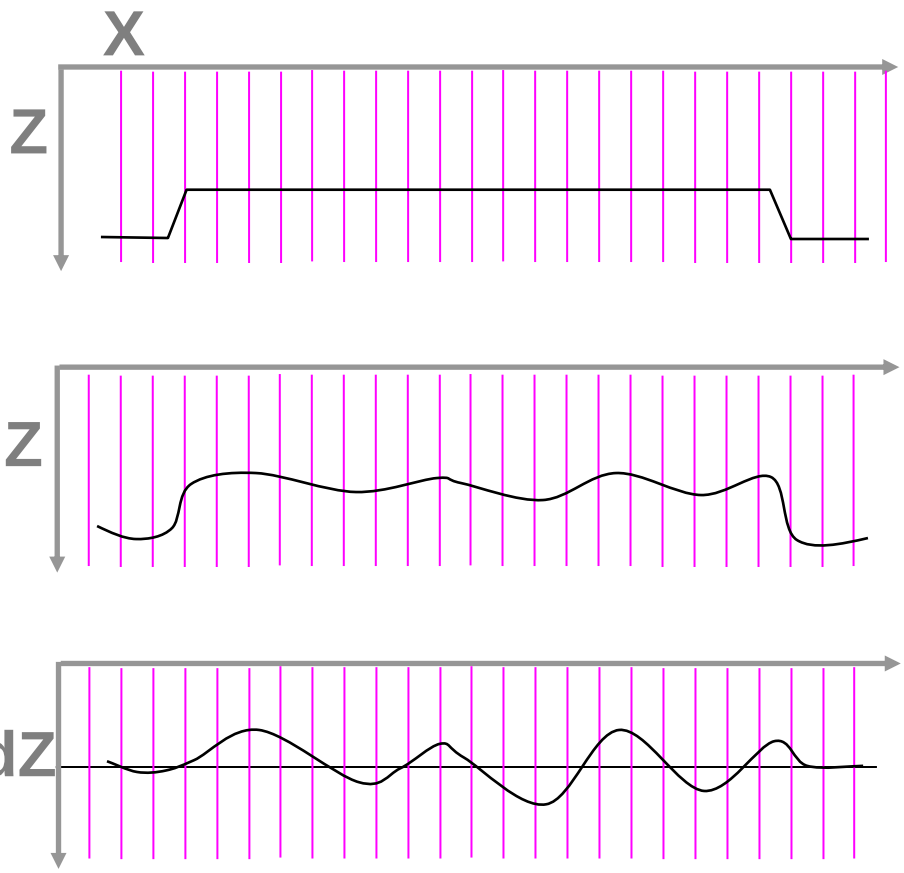
Actual deep
to prognosis

real *minus* mapped surface

Actual shallow
to prognosis

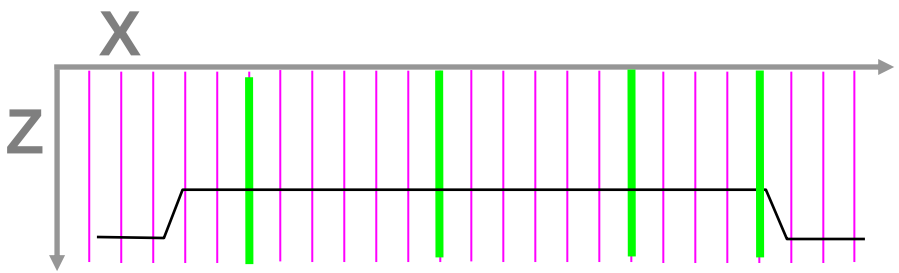
Why biased estimates?

Random sampling: no bias

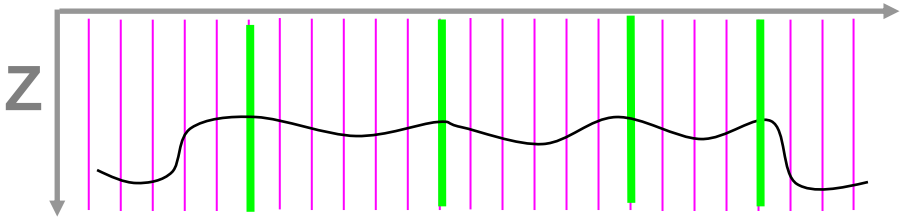


Why biased estimates?

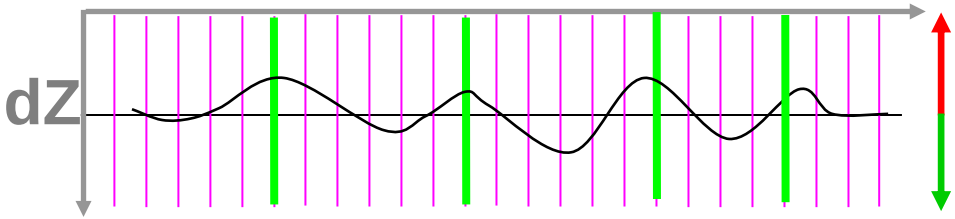
Selective sampling: bias*



real surface



seismically mapped surface



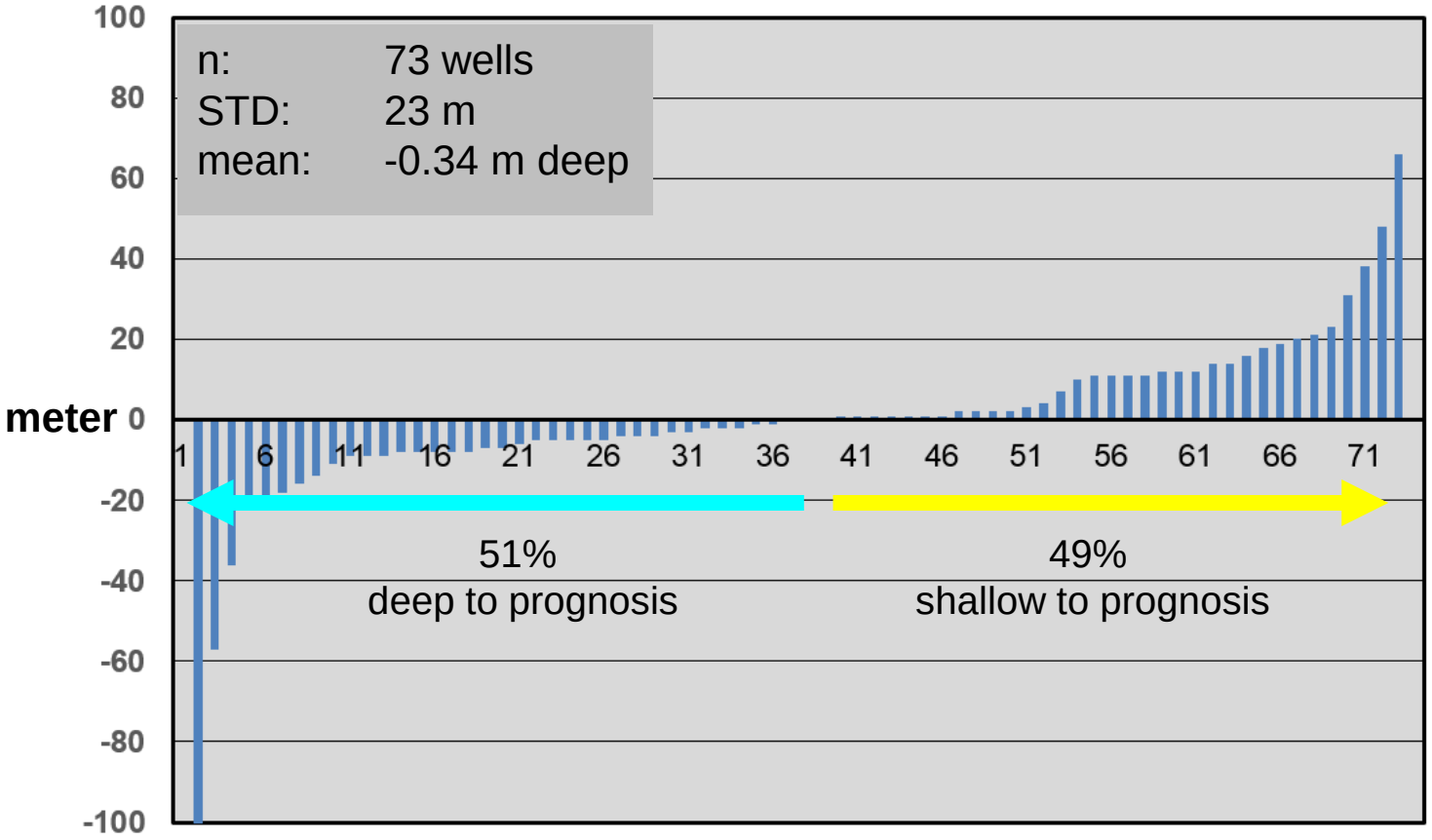
Actual deep to prognosis

real *minus* mapped surface

Actual shallow to prognosis

**** Structural height is an important selection criterion***

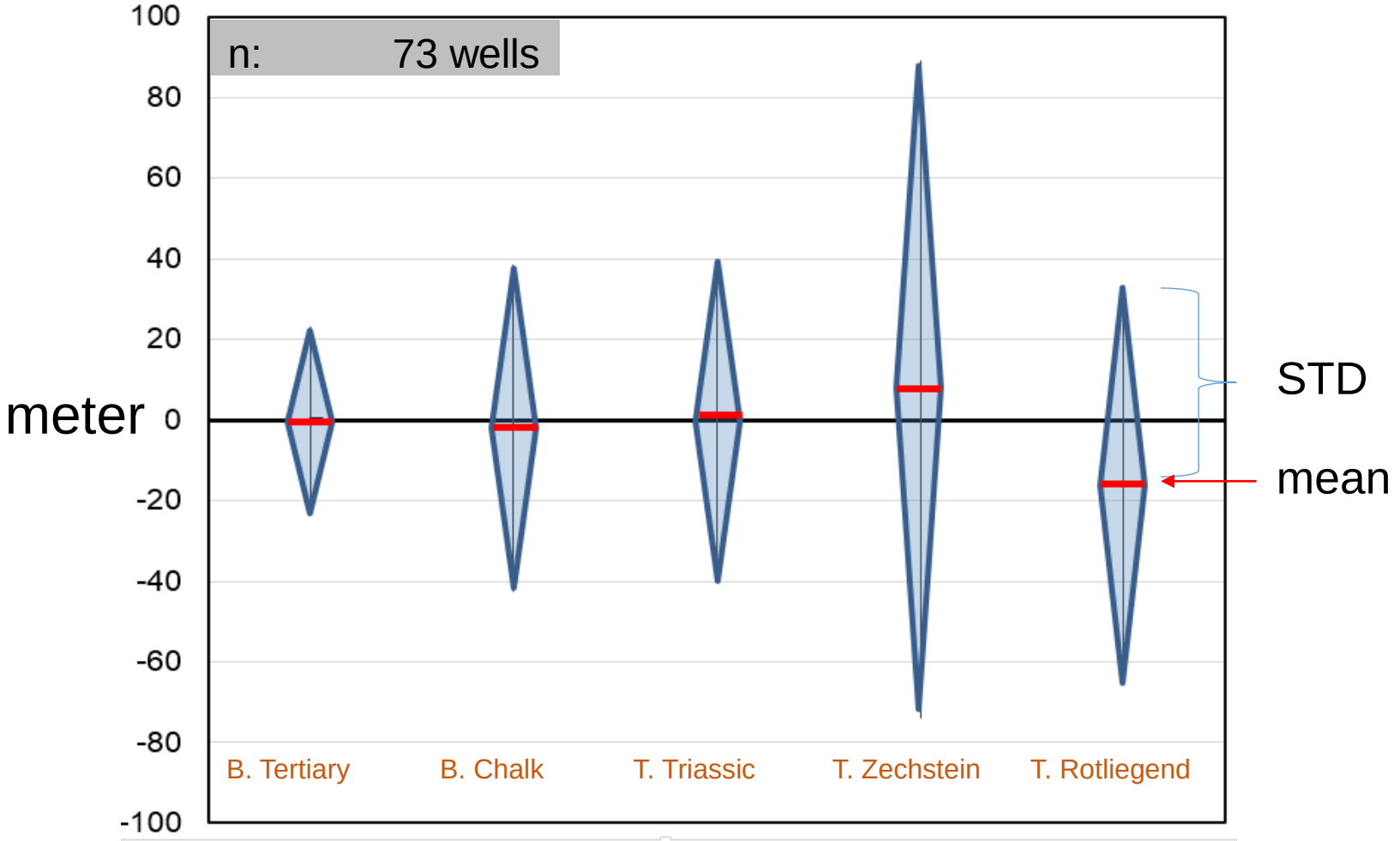
Depth errors at Base Tertiary (overburden reflector)



Depth error: 2.5% Prediction bias small (0.04%)

Depth errors for target & key overburden reflectors

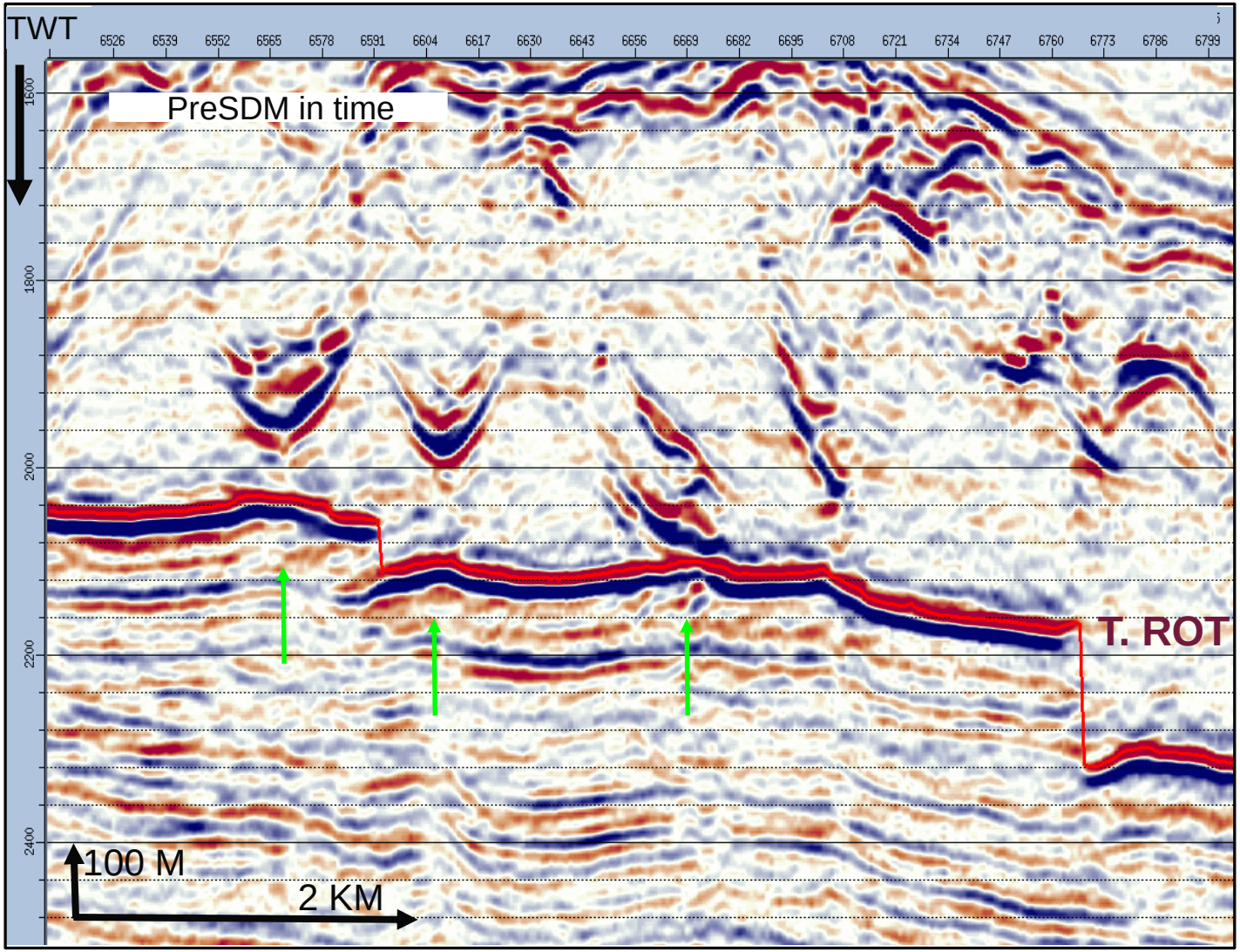
expressed in standard deviation & mean



Depth bias increases from 0.3 m (0.04% at B. Tertiary)
to 15.8 m (0.5% at Rotliegend target)

Chasing highs: true or phantom?

Phantom highs on depth maps can be caused by imperfect TD-conversion (amongst others)



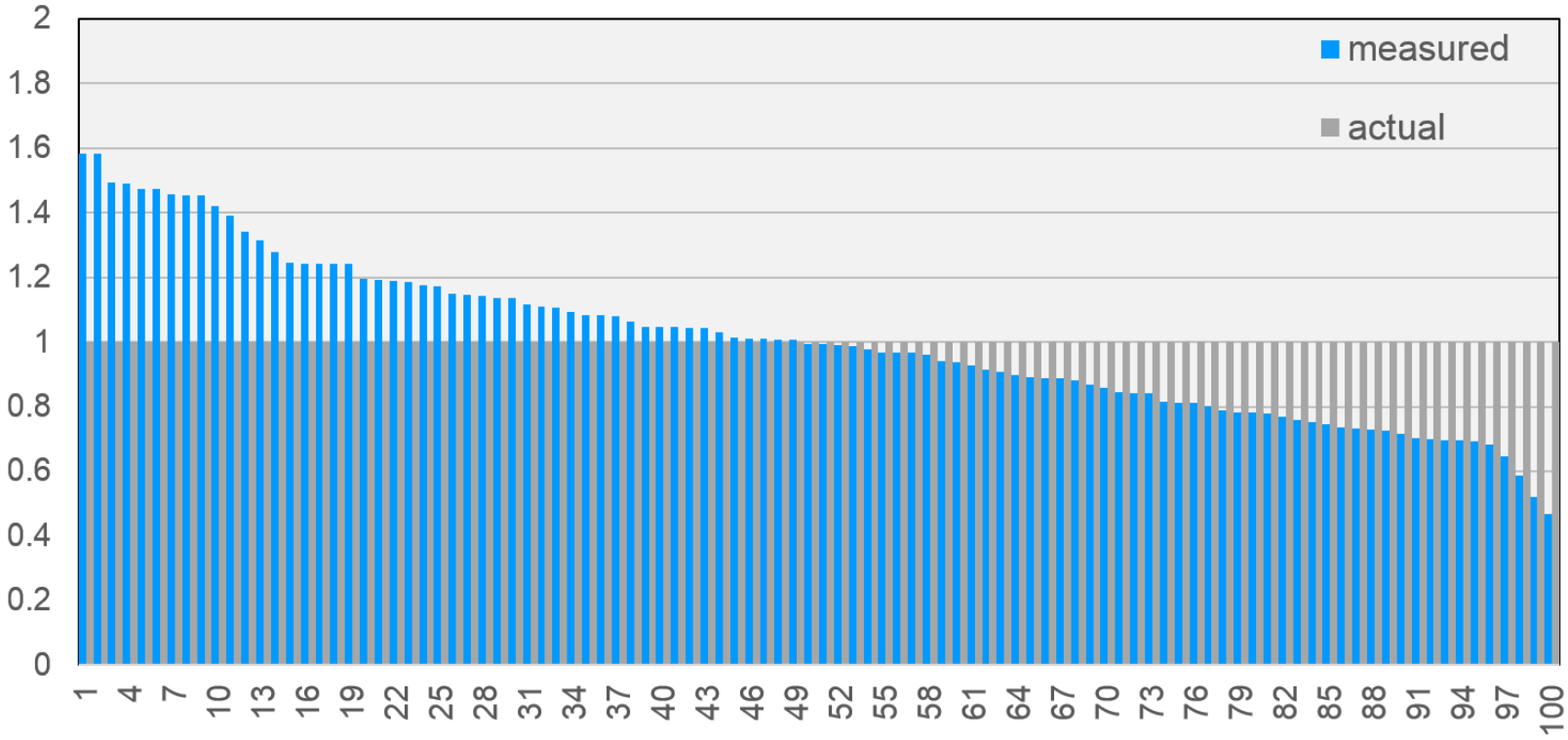
Selection Bias affecting volumes (1)

Assumptions

1. *Hypothetical* prospect portfolio: 100 prospects all containing 1 bcm GIIP.
2. Explorers evaluate imperfect data to asses prospect volumes and build portfolio.
3. Portfolio drilled in order of attractiveness (volume is key driver!)
4. Only *best part* of portfolio to be drilled.

Selection Bias affecting volumes (2)

Prospect portfolio (ranked on GIIP)



Post campaign conclusion: *actuals do fall short of expectation!*

conclusions

- Average depth error: 38 m (1std) i.e.1.2%
- Most depth errors due to TD conversion (rather than picking wrong loop)
- Bias might be explained by *Selection Bias*
- Bias (10m too *deep*) causes overestimate in volumes
- Proper depth conversion remains a challenge…

Questions?

Acknowledgements:
NAM, Wintershall, Engie, Total, ONE, Dana, Taqa, Petrogas, Vermilion,Tulip Oil, Hansa, Centrica, Sterling.

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