

# Net exhumation estimation using an effective-medium technique based on seismic travelttime measurements

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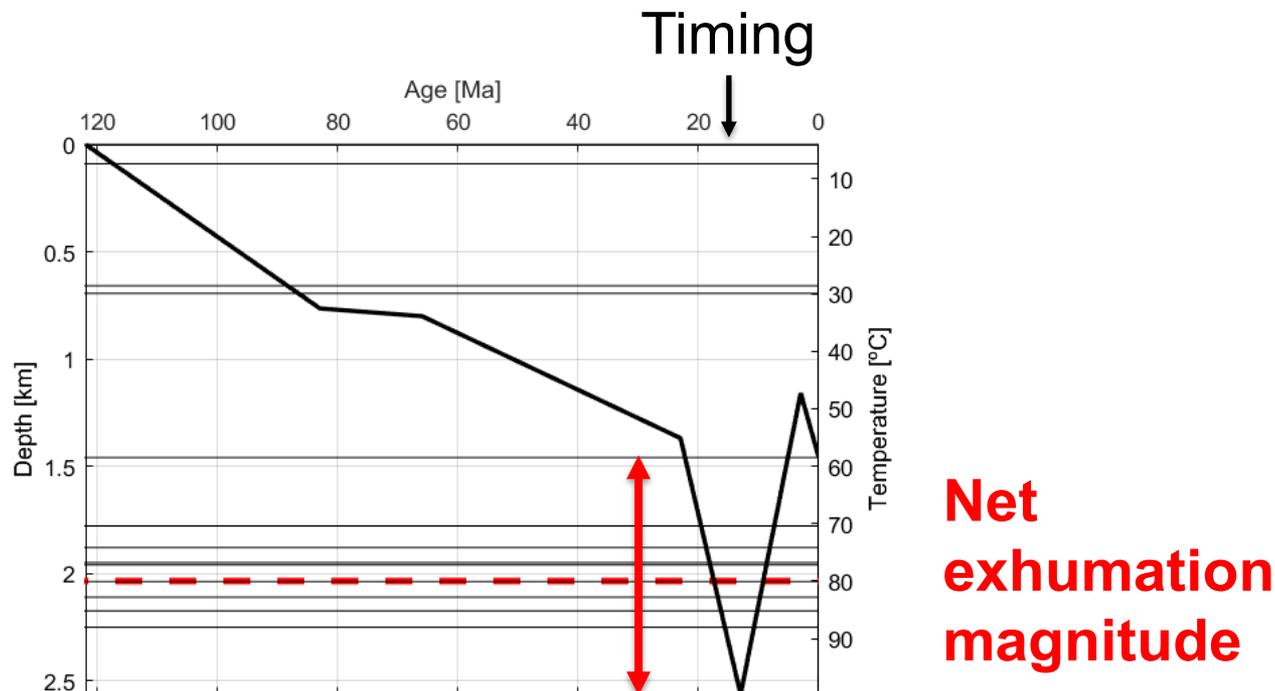
Trondheim, 24<sup>th</sup> April, 2018

# Objective

- The presentation aims to demonstrate the use of seismic travelttime measurements to estimate the magnitude of net exhumation/uplift in sedimentary basin areas.
- Acknowledgement
  - NTNU supporting the ongoing research on net erosion estimation
  - NPD and Schlumberger for data
  - CREWES and Gary Margrave for Ray Tracing facility
  - NRC for EAGE Conference & Exhibition 2018 Sponsorship

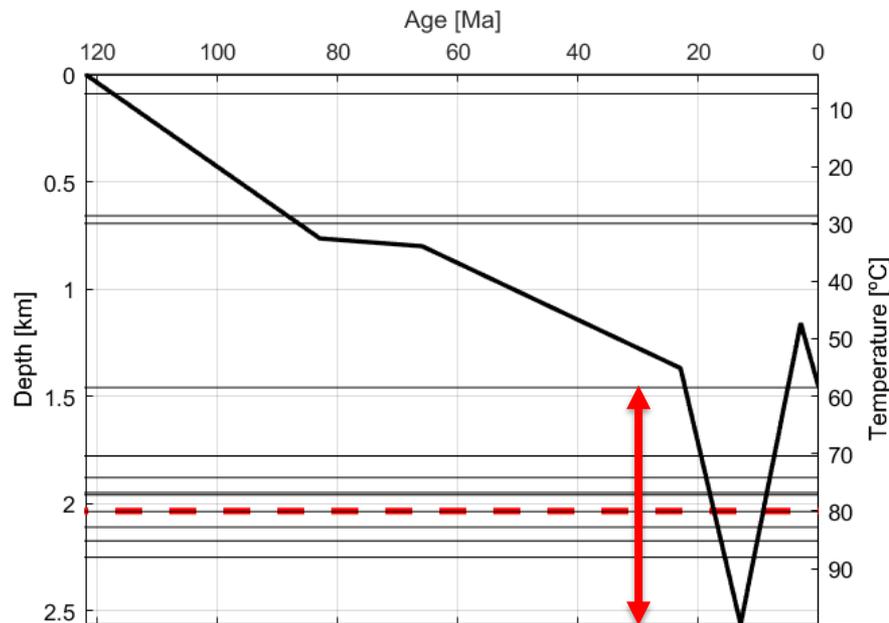
# What is net exhumation?

- Net exhumation magnitude: the difference between the present day burial depth of a reference unit and its maximum burial depth prior to exhumation (Corcoran and Dore, 2005).



# Why net erosion/exhumation studies?

- The magnitude of uplift may affect HC potential in an area
  - Source rock maturation might stop
  - Poorer reservoir quality than anticipated from present day depth
  - Sealing capacity might deteriorate



- Magnitude
- Timing

# Net erosion estimation techniques

## Well data

- Sediment compaction depth trends
  - Link to geophysical data
- Sandstones diagenesis
- Clay mineralogy
- Vitrinite reflectance
- Apatite fission-tracks
- T-Max

# Net erosion estimation techniques

## Well data

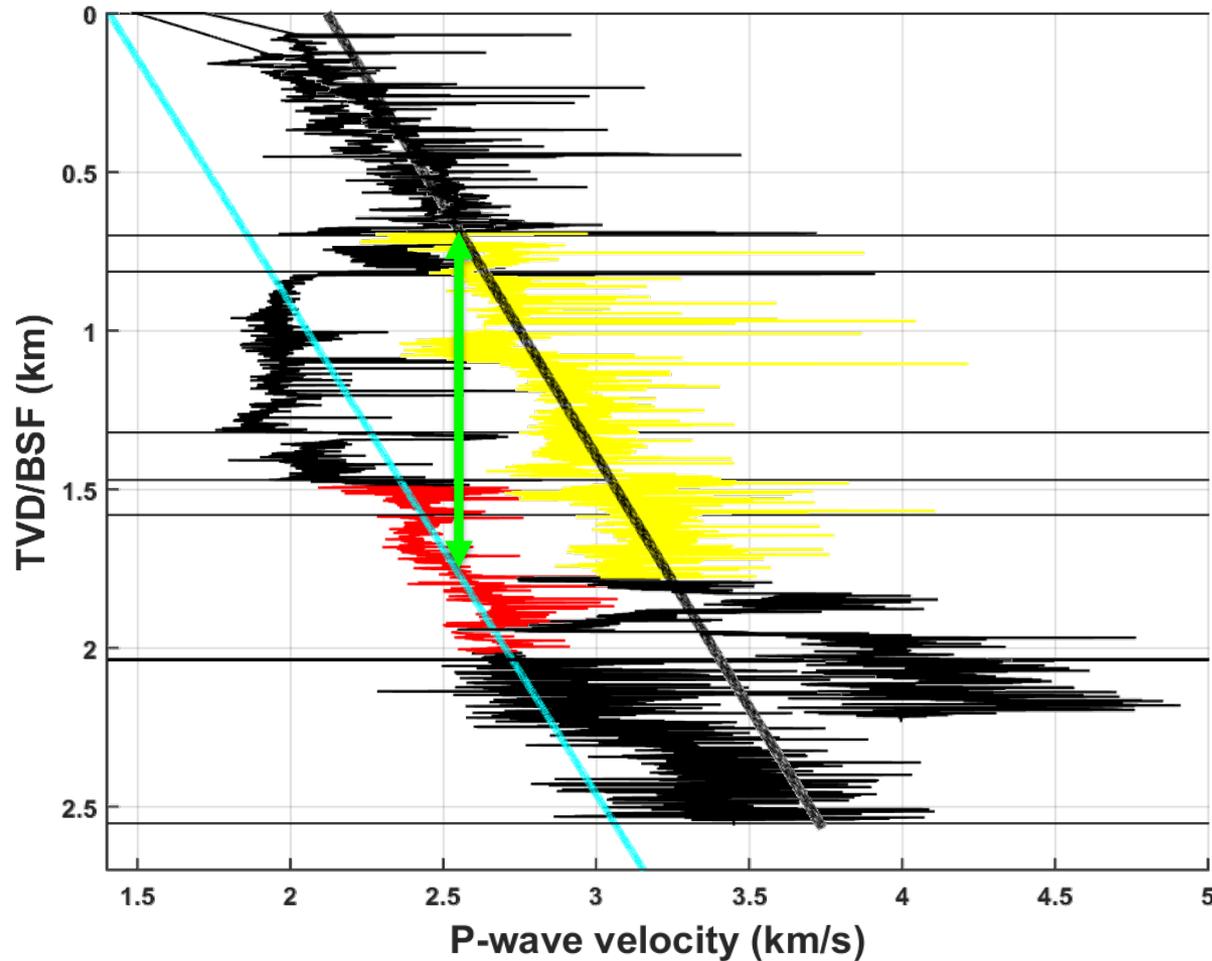
- **Sediment compaction depth trends**
  - Link to geophysical data
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- Clay mineralogy
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# Sediment compaction depth trend technique

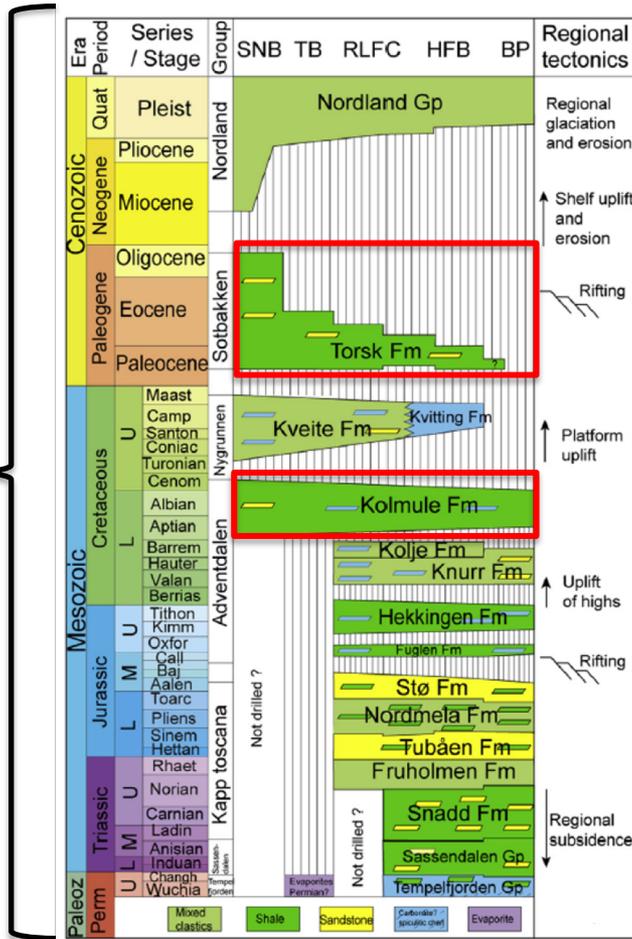
1. Compaction is an irreversible process
2. Basin has experienced equilibrium compaction
3. Homogeneous formation found in reference and uplifted areas.
  - Preferably thick shale units but sandstones can be used also

# Reference compaction depth trend

## Interval velocity-depth trend



# Why an effective-medium technique?



Modified from Baig et al. (2016).

At severely uplifted areas



Eroded

At non-uplifted areas



Wells drilled do not reach the formation

**Shale compaction depth-trend technique cannot be used**

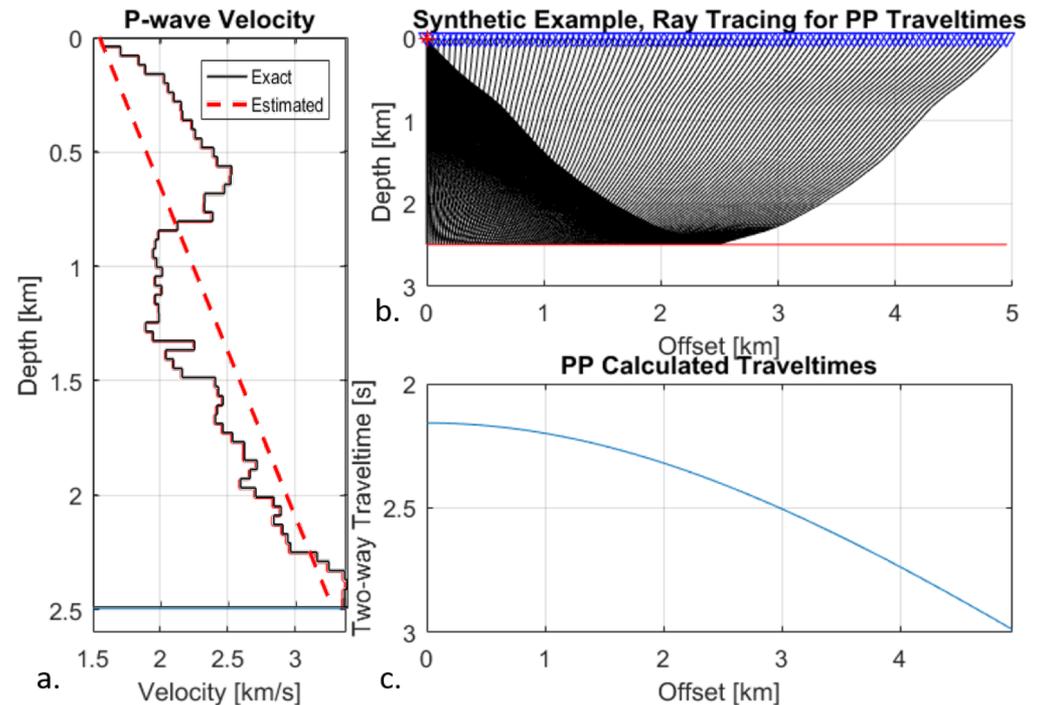
# Methodology

## 1. Large-Offset PP traveltimes, starting from the seabed on:

- Reference (non-uplifted) area
- Area suspected to be uplifted

## 2. Stovas and Ursin (2007) method to estimate a linear P-wave velocity function

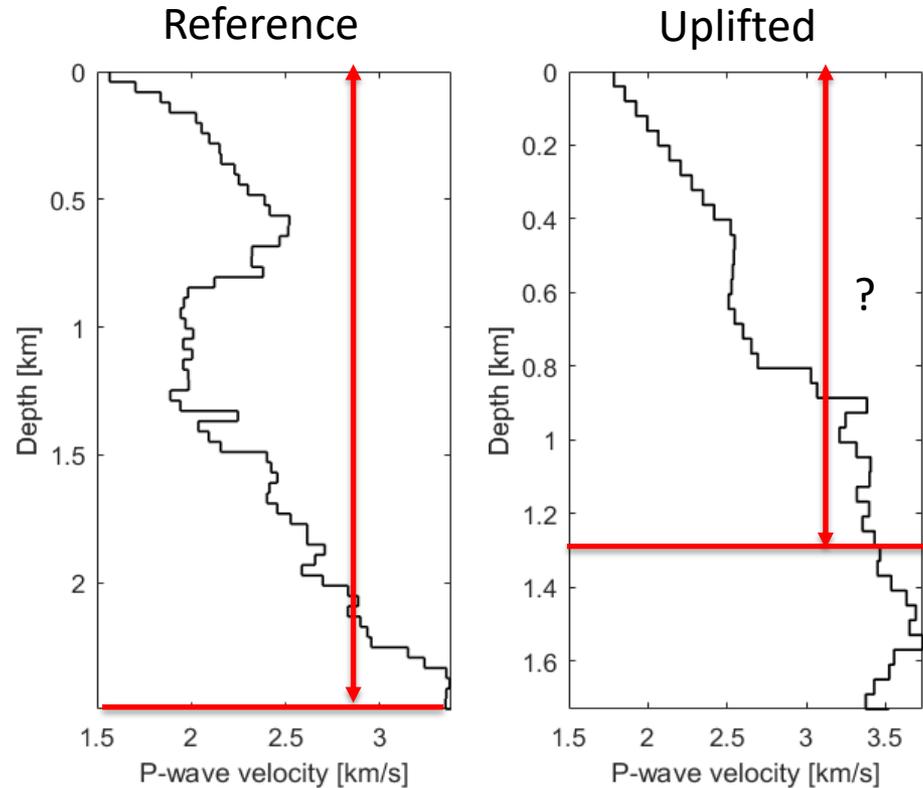
- $t(x) \rightarrow$  Velocity analysis  $\rightarrow t_0, V_{nmo}, S$  for top and base
- Finding the solution of a dix-type equation
- Computing  $V_{p0}, B_p,$  and  $H$  using analytical expressions



# Methodology

3. When are the two columns comparable?

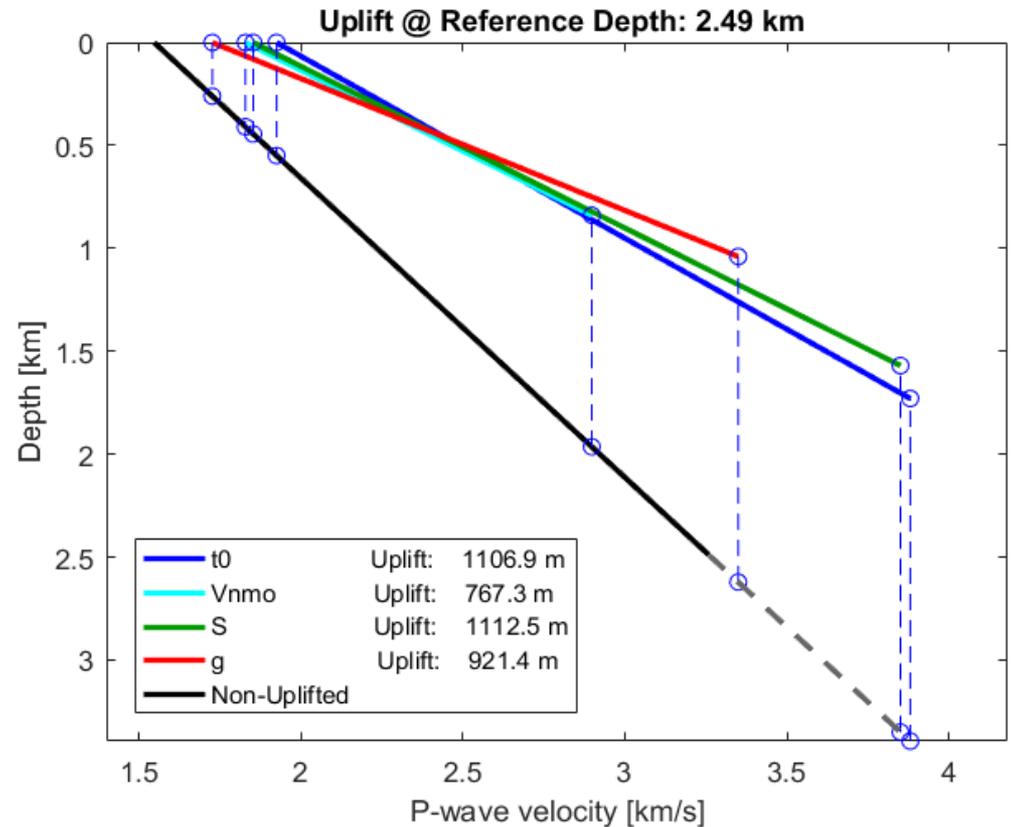
- $t_{0_{\text{ref}}} = t_{0_{\text{uplift}}}$
- $V_{nmo_{\text{ref}}} = V_{nmo_{\text{uplift}}}$
- $S_{\text{ref}} = S_{\text{uplift}}$
- $g_{\text{ref}} = g_{\text{uplift}}$  (Al-Chalabi. [1974])



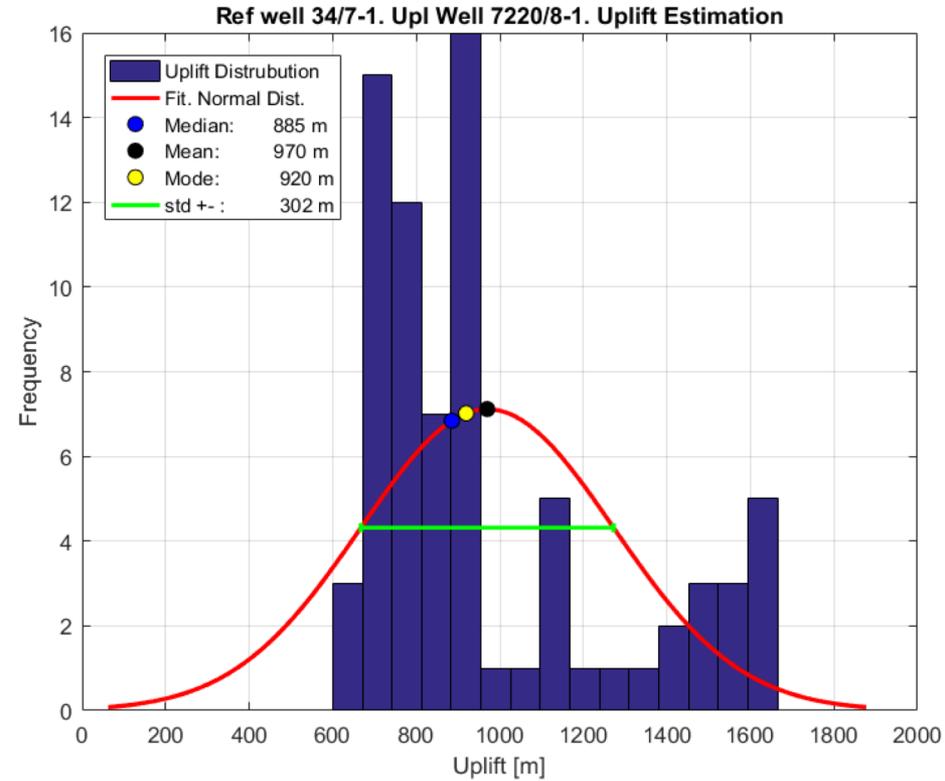
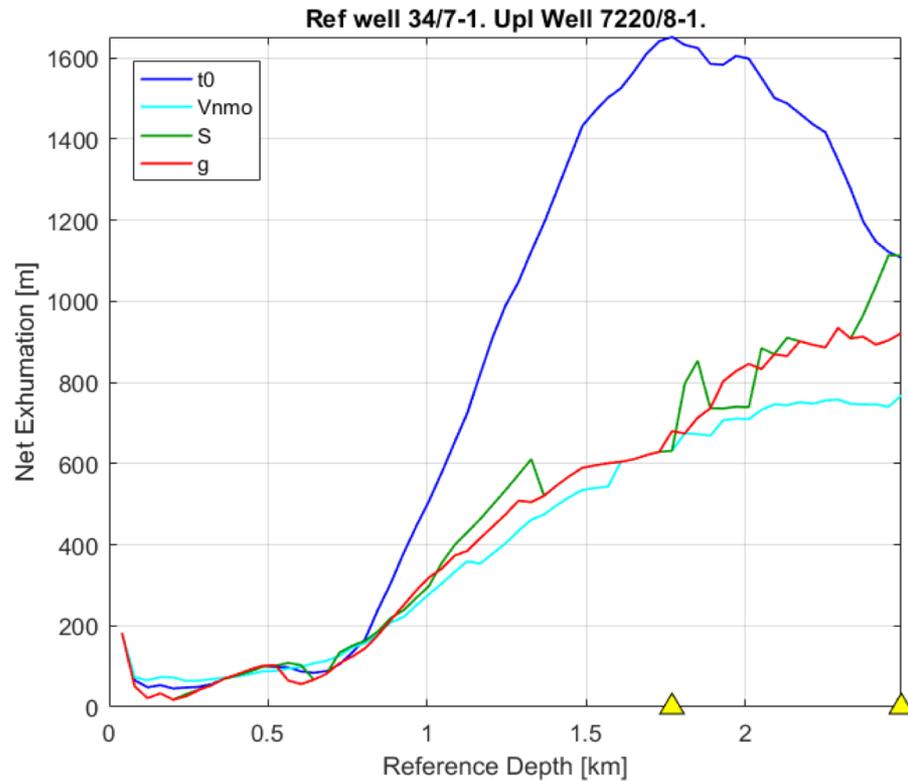
# Methodology

3. When are the two columns comparable?

- $t_{0_{ref}} = t_{0_{uplift}}$
- $V_{nmo_{ref}} = V_{nmo_{uplift}}$
- $S_{ref} = S_{uplift}$
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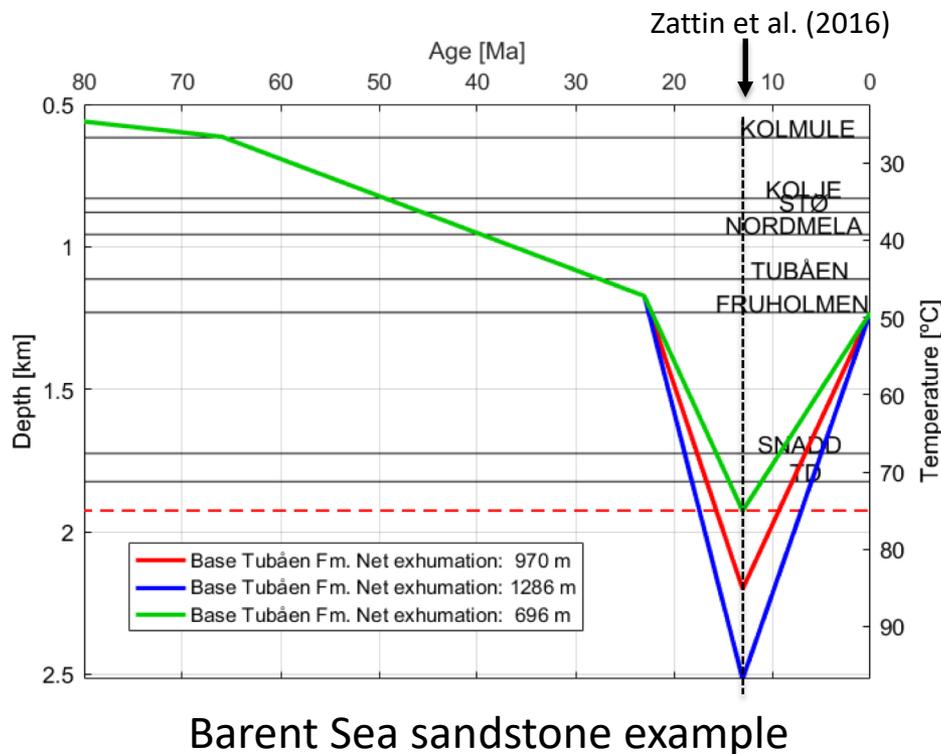


# Net exhumation magnitude estimation

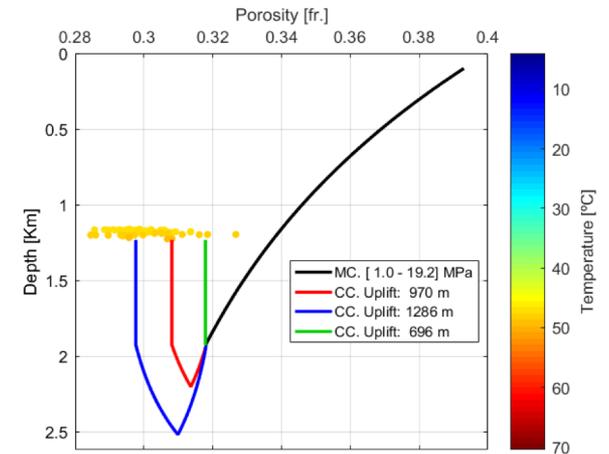


# Simplified burial history of a sandstone: Magnitude and timing

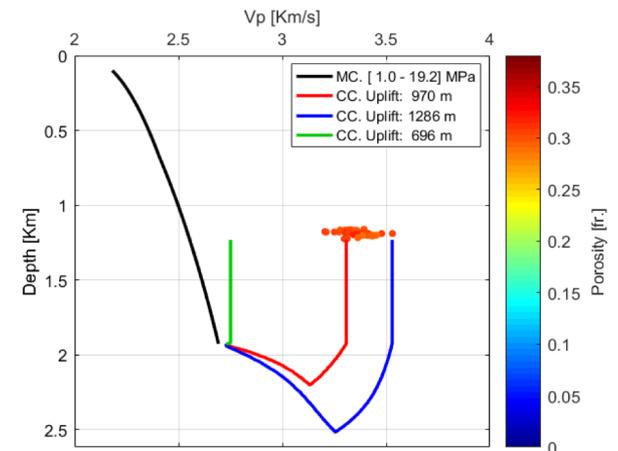
Burial history is recreated using the minimum, mean, and maximum net exhumation estimates



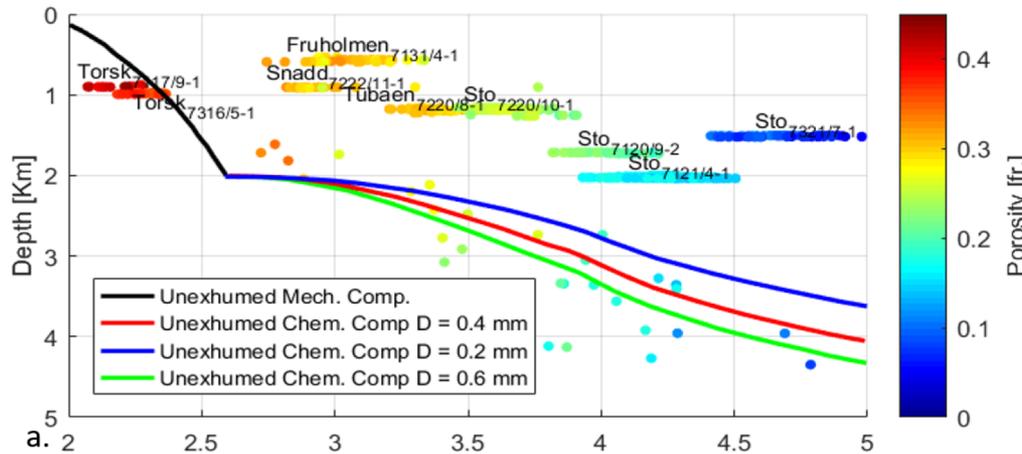
Lander & Walderhaug (1999)



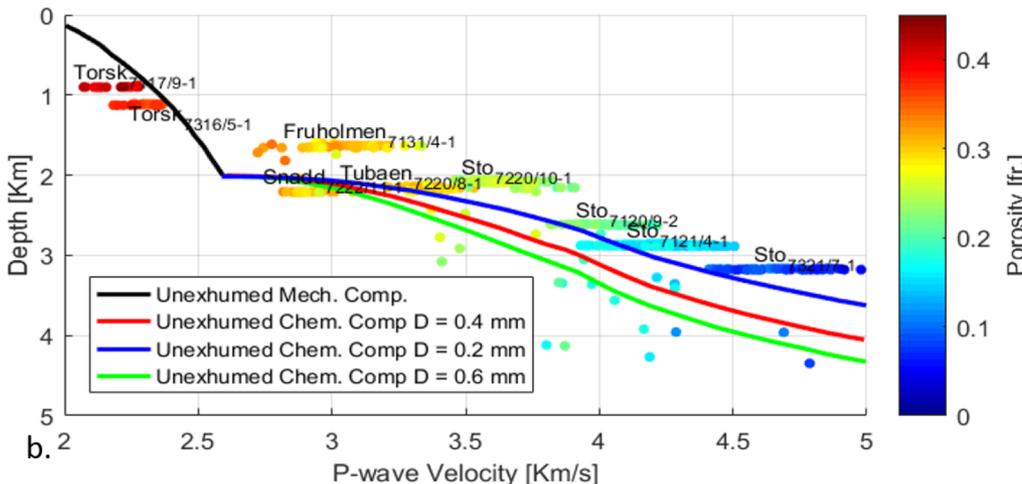
Dvorking & Nur (1996, 1999)



# Evaluation of the net exhumation estimates: A sandstone velocity comparison



No depth  
correction applied



Depth corrected  
using the  
estimated net  
exhumation  
magnitudes

Vucelic et al. (2017)

# Conclusion

- Effective-medium compaction-based method that allows for estimating net exhumation magnitudes from travelttime measurements.
- The net exhumation estimates are in agreement with published net uplift magnitudes.
- The burial history curves of clean sandstones constructed using our net exhumation estimates, explain the petrophysical properties observed at well location.
- The velocity of the Barents Sea sandstones corrected for exhumation using our estimates is in agreement with the velocity of non-uplifted sands from the Norwegian Sea and North Sea.

Thank you

# References

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