The Permian-Triassic boundary across the Barents Shelf: an intricate record of climate change, mass extinction, recovery, and basin reorganisation

Work done when I was at UiO, continues now at RWTH-Aachen

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5 - Natural History Museum, The University of Oslo, Norway
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Palaeogeography, Palaeoclimatology, Palaeoecology
Volume 554, 15 September 2020, 109732

A new high-resolution stratigraphic and palaeoenvironmental record spanning the End-Permian Mass Extinction and its aftermath in central Spitsbergen, Svalbard

V. Zuchuat [a], A.R.N. Sleveland [a], R.J. Twitchett [b], H.H. Svensen [c], H. Turner [d], L.E. Augland [c], M.T. Jones [c], Ø. Hammer [d], B.T. Hauksson [e], H. Haflidason [f], I. Midtkandal [a], S. Planke [c, g]

Open access in Palaeo[3]

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Article | Published: 17 August 2020

A nutrient control on marine anoxia during the end-Permian mass extinction

Martin Schobben, William J. Foster, Arve R. N. Sleveland, Valentin Zuchuat, Henrik H. Svensen, Sverre Planke, David P. G. Bond, Fons Marcelis, Robert J. Newton, Paul B. Wignall & Simon W. Poulton

Not open access

Palaeogeography, Palaeoclimatology, Palaeoecology
Volume 581, 1 November 2021, 110637

Response of macrobenthic trace maker community to the end-Permian mass extinction in Central Spitsbergen, Svalbard

F.J. Rodríguez-Tovar [a], J. Dorador [a], V. Zuchuat [b], S. Planke [b, c], Ø. Hammer [d]

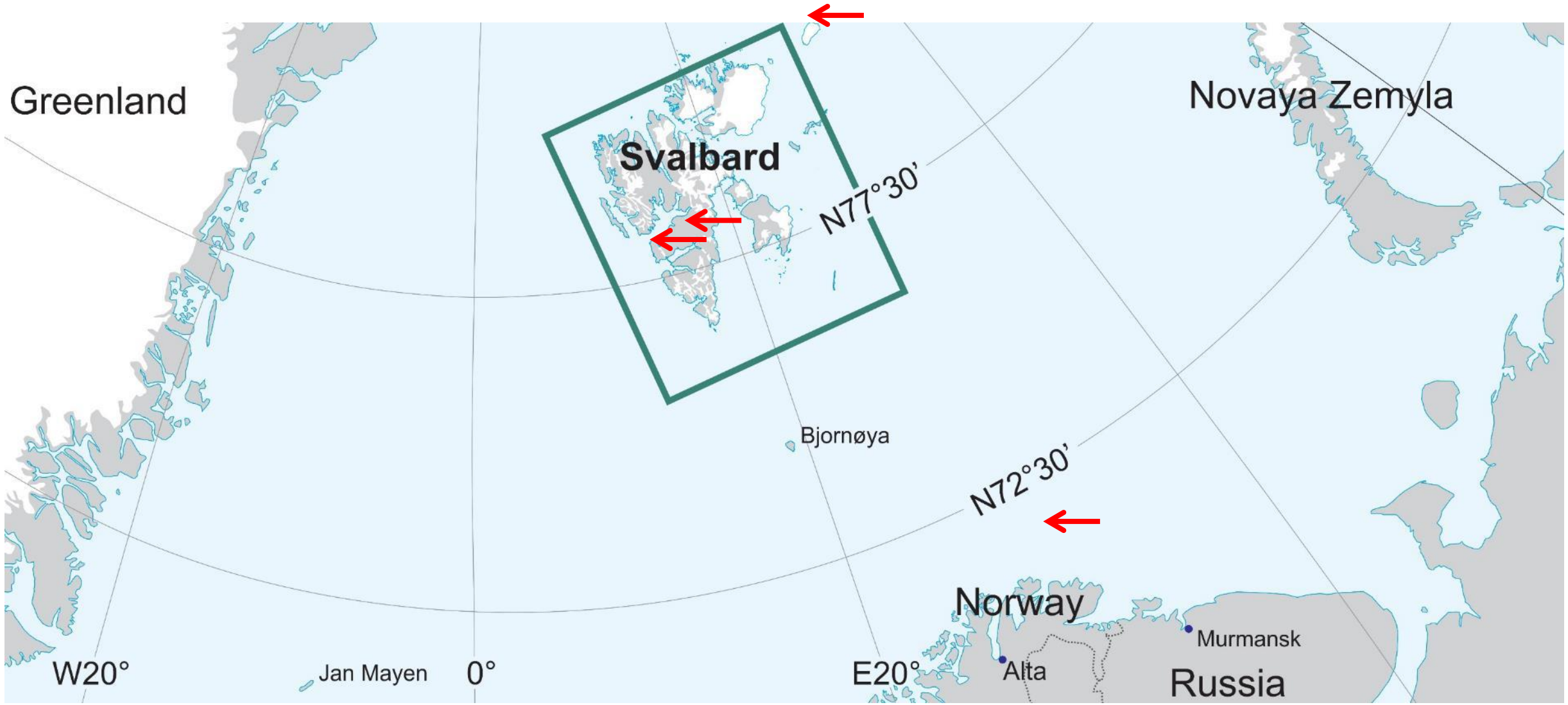
0. Rationale

- People agree on consequences of mass extinctions, but dispute the trigger mechanism(s?)
- Specific to Permian-Triassic Boundary: Siberian Traps Large Igneous Province
- Impact on boreal Realm?

- Historic research in the Arctic: outcrop

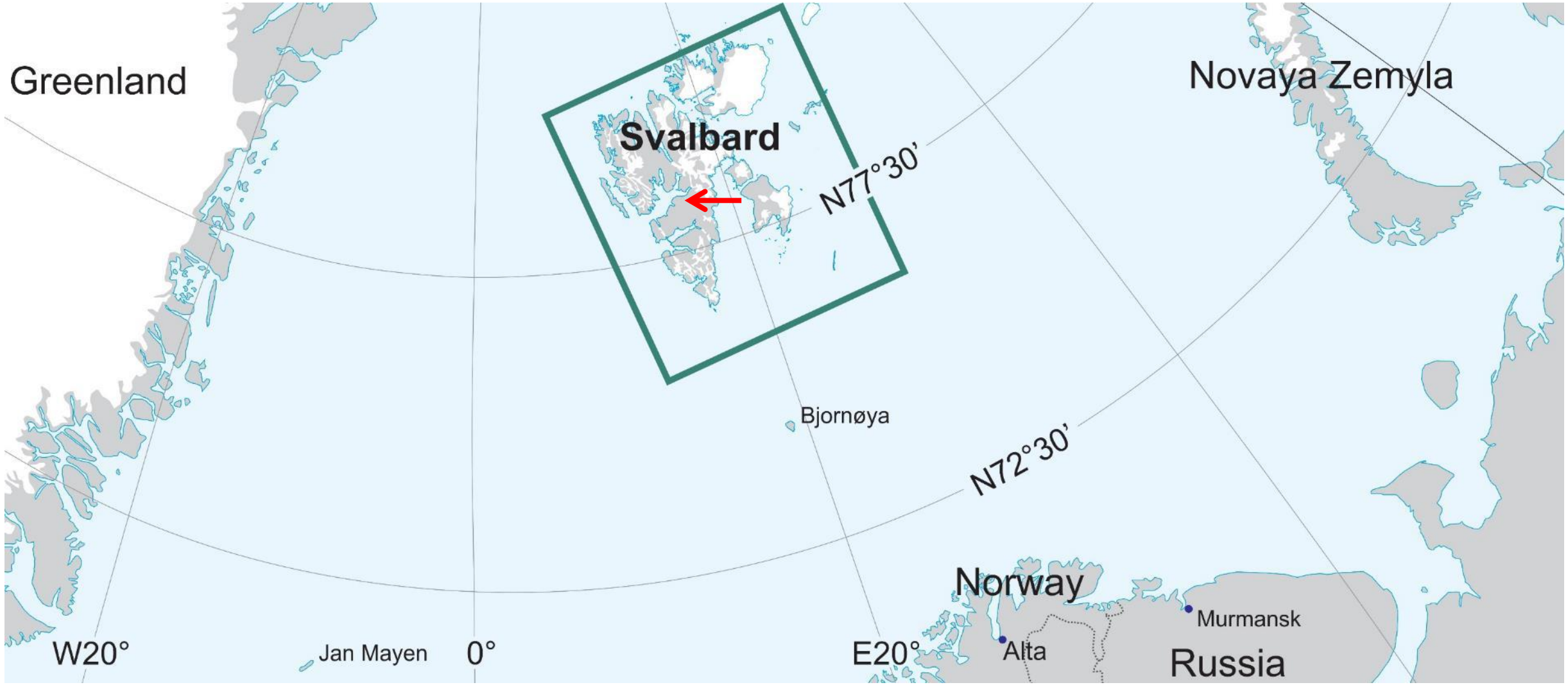
→ Cores = High-resolution version of the outcrop

1. Study area



Modified from Lord (2013)

1. Study area



Modified from Lord (2013)

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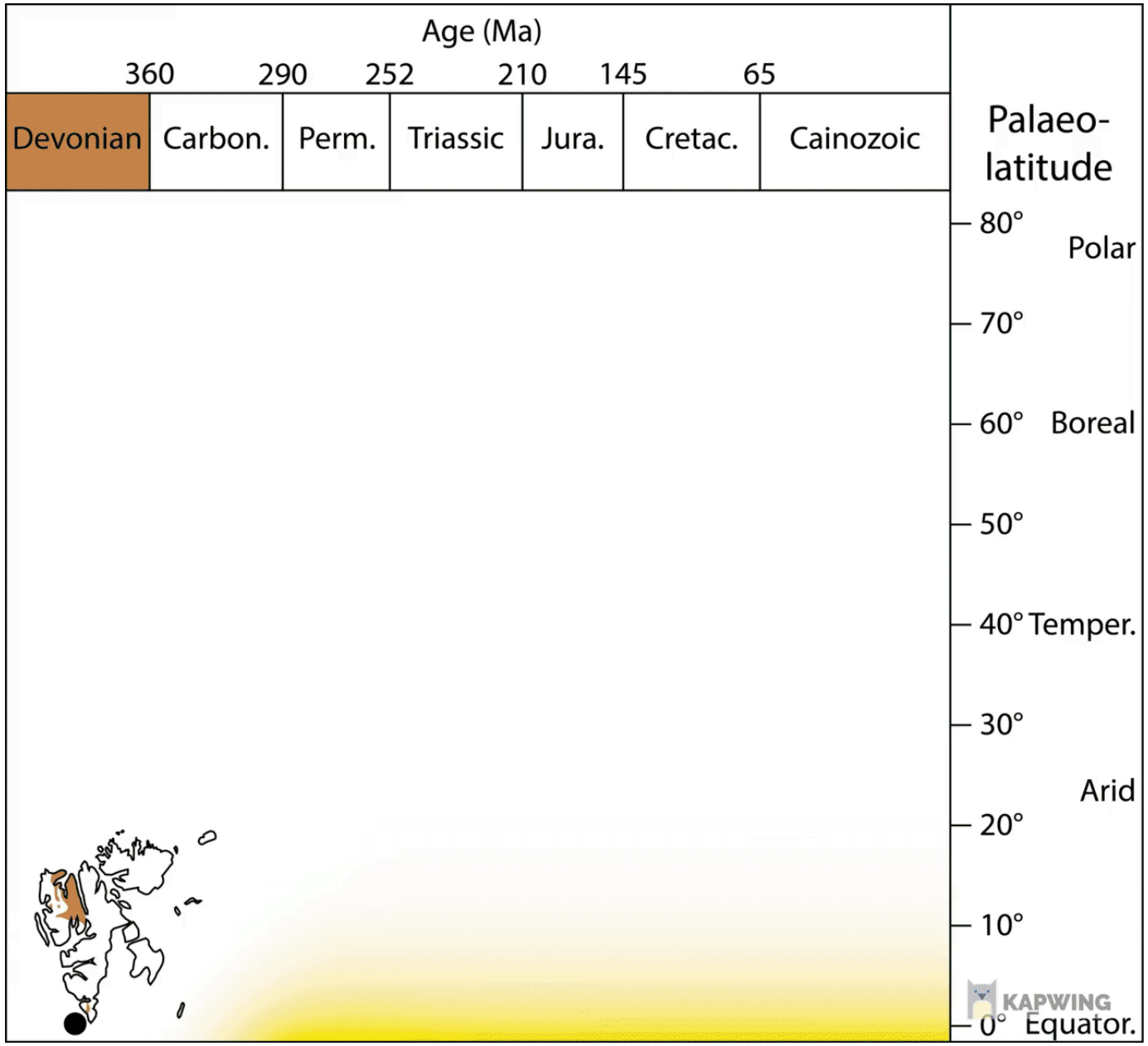
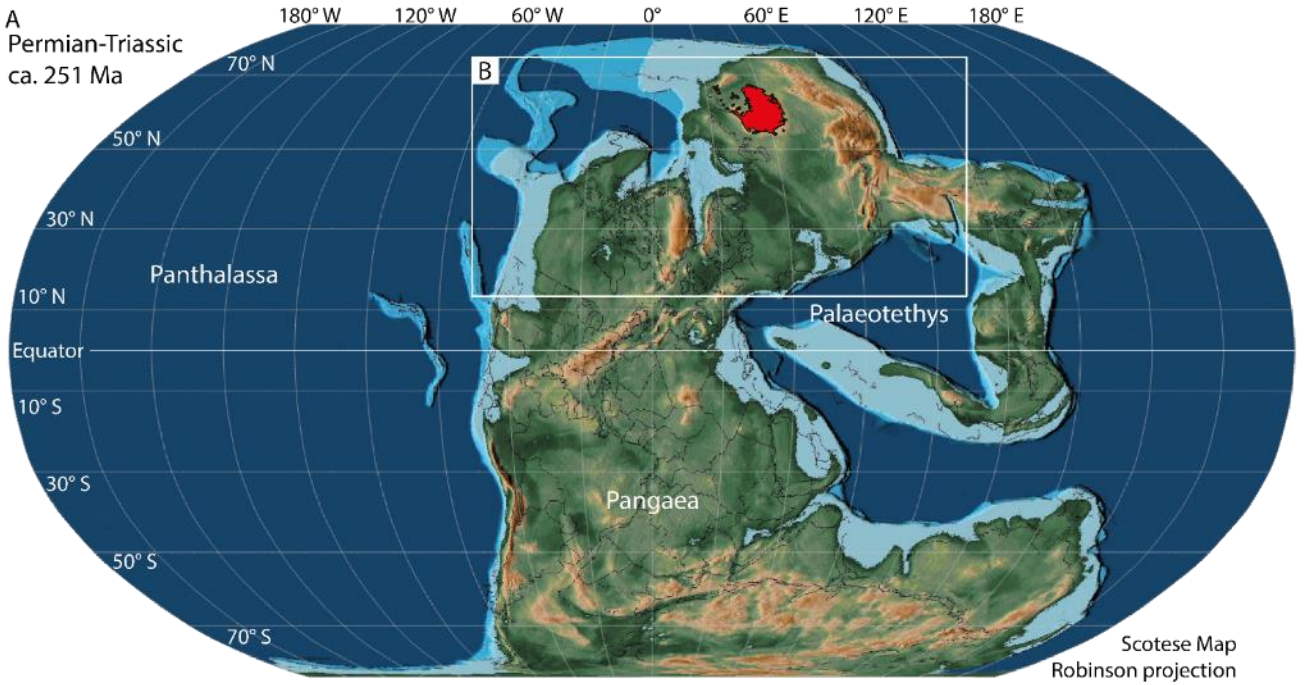
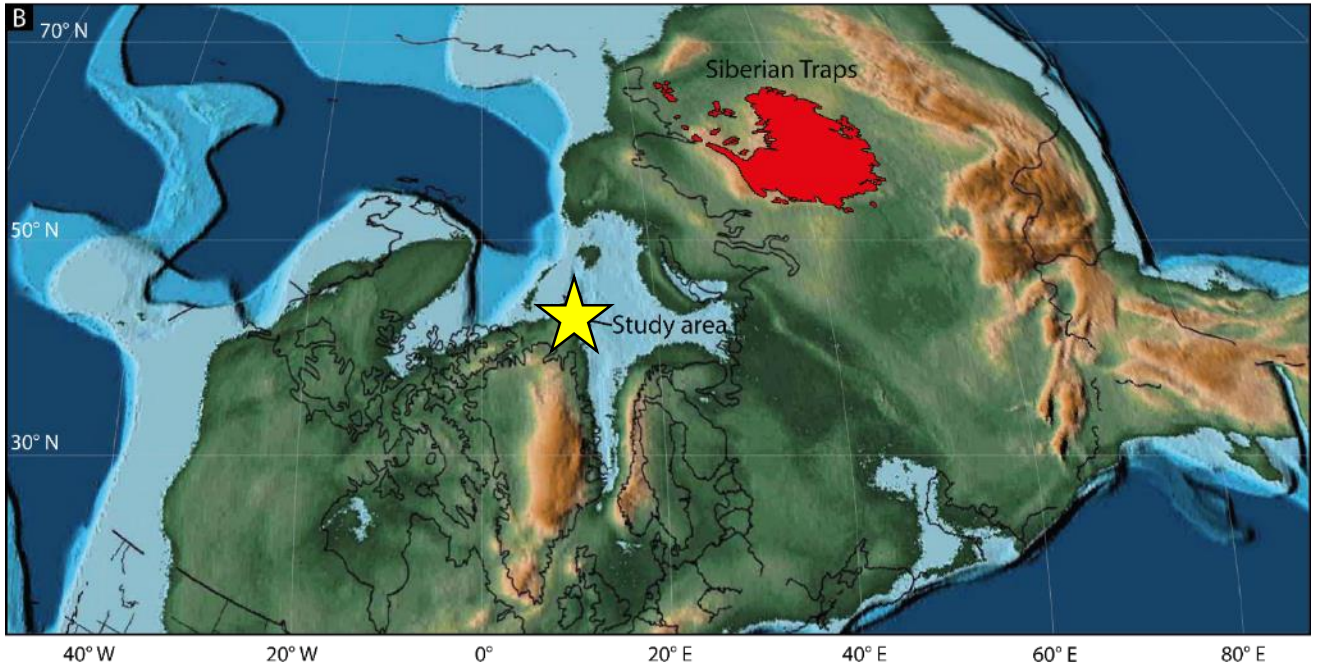


Data from Elvevold *et al.* (2007) and Lord (2013)

1. Study area





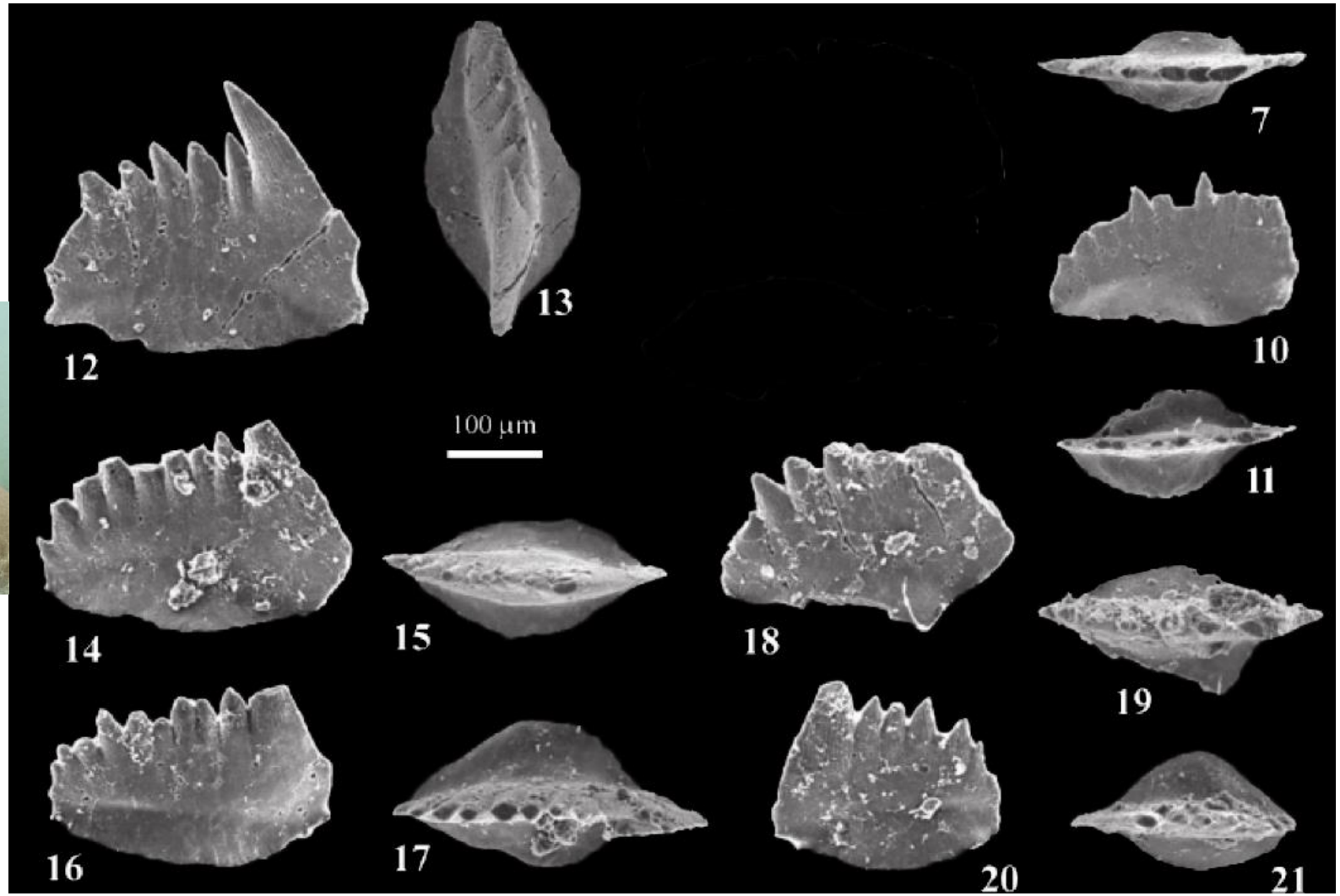
Rodríguez-Tovar et al. (2021)

1.1. Permian-Triassic GSSP

Hindeodus parvus

Looks like a worm

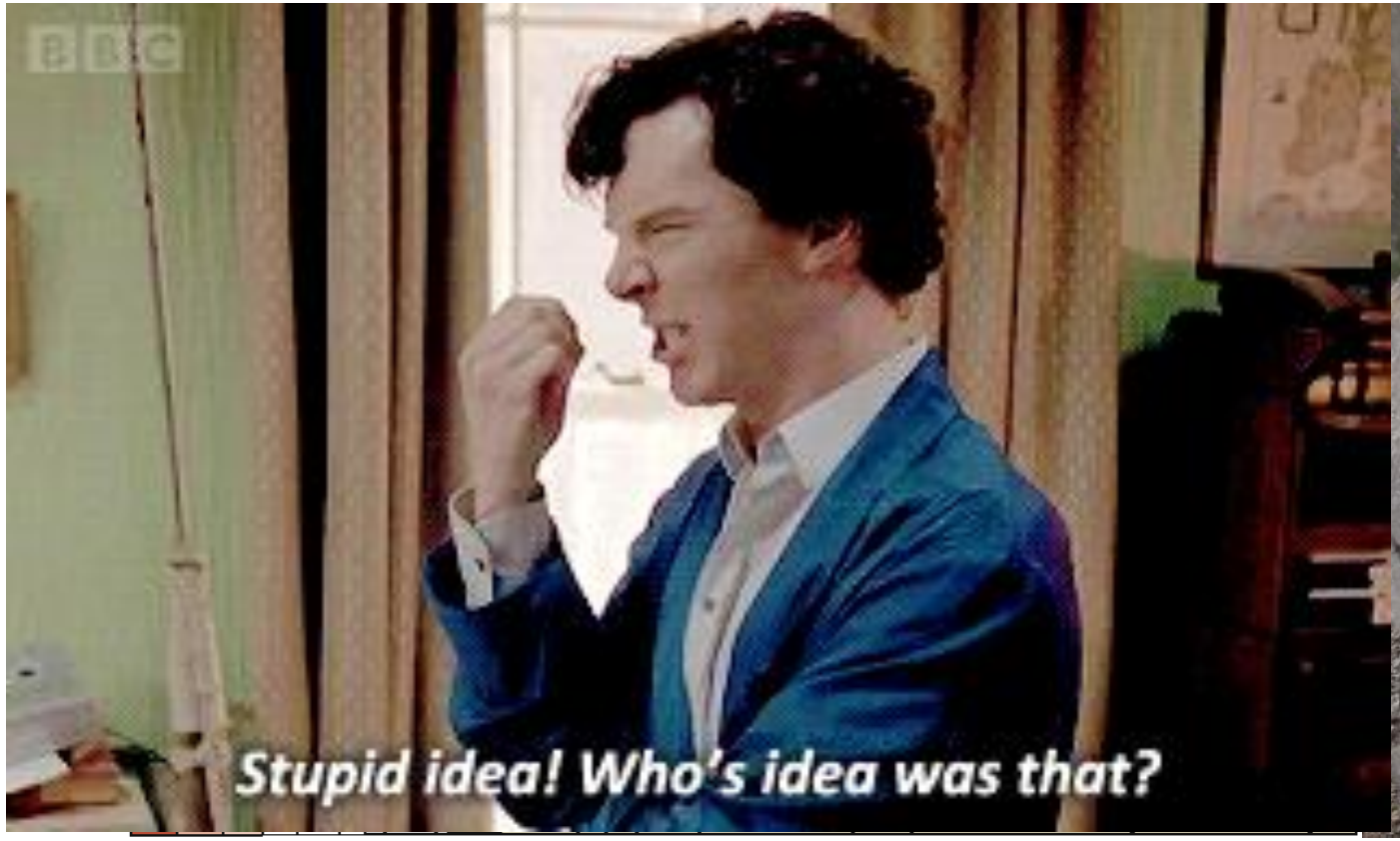
Graphic by alphynix



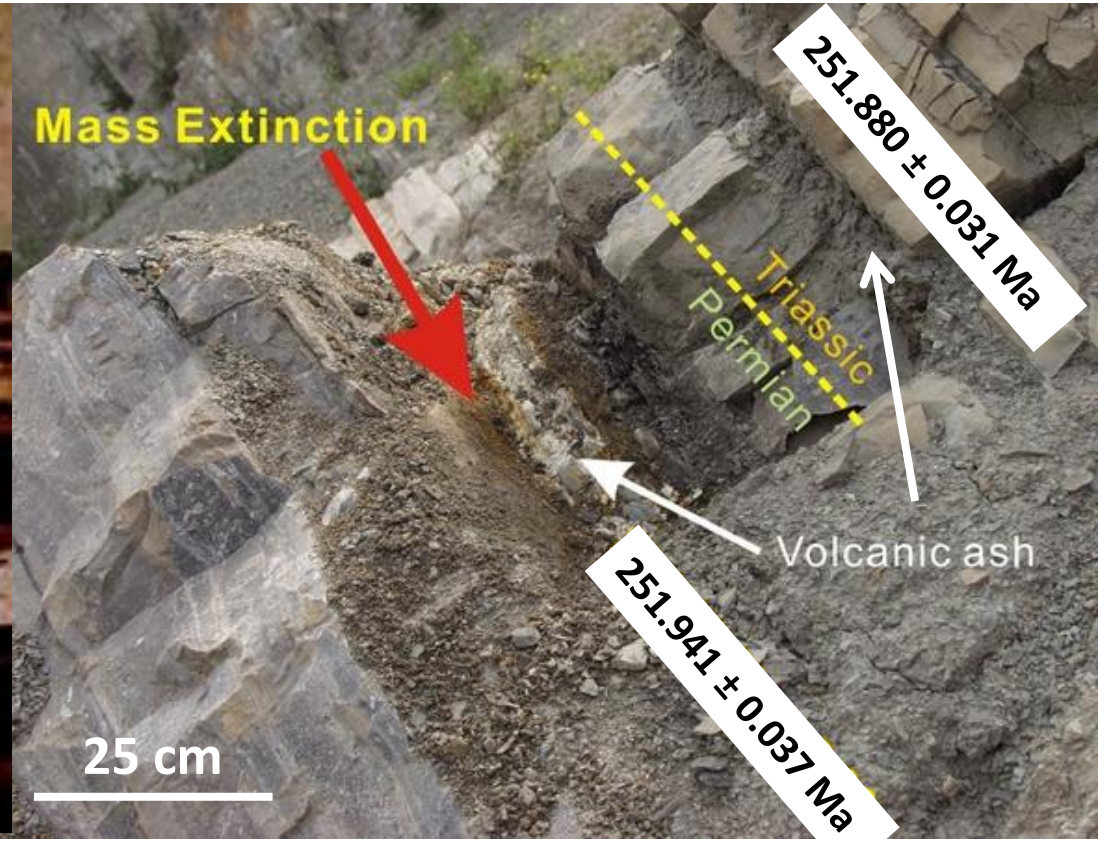
Modified, after Sudar *et al.* (2008)

1.1. Permian-Triassic GSSP

Problems…



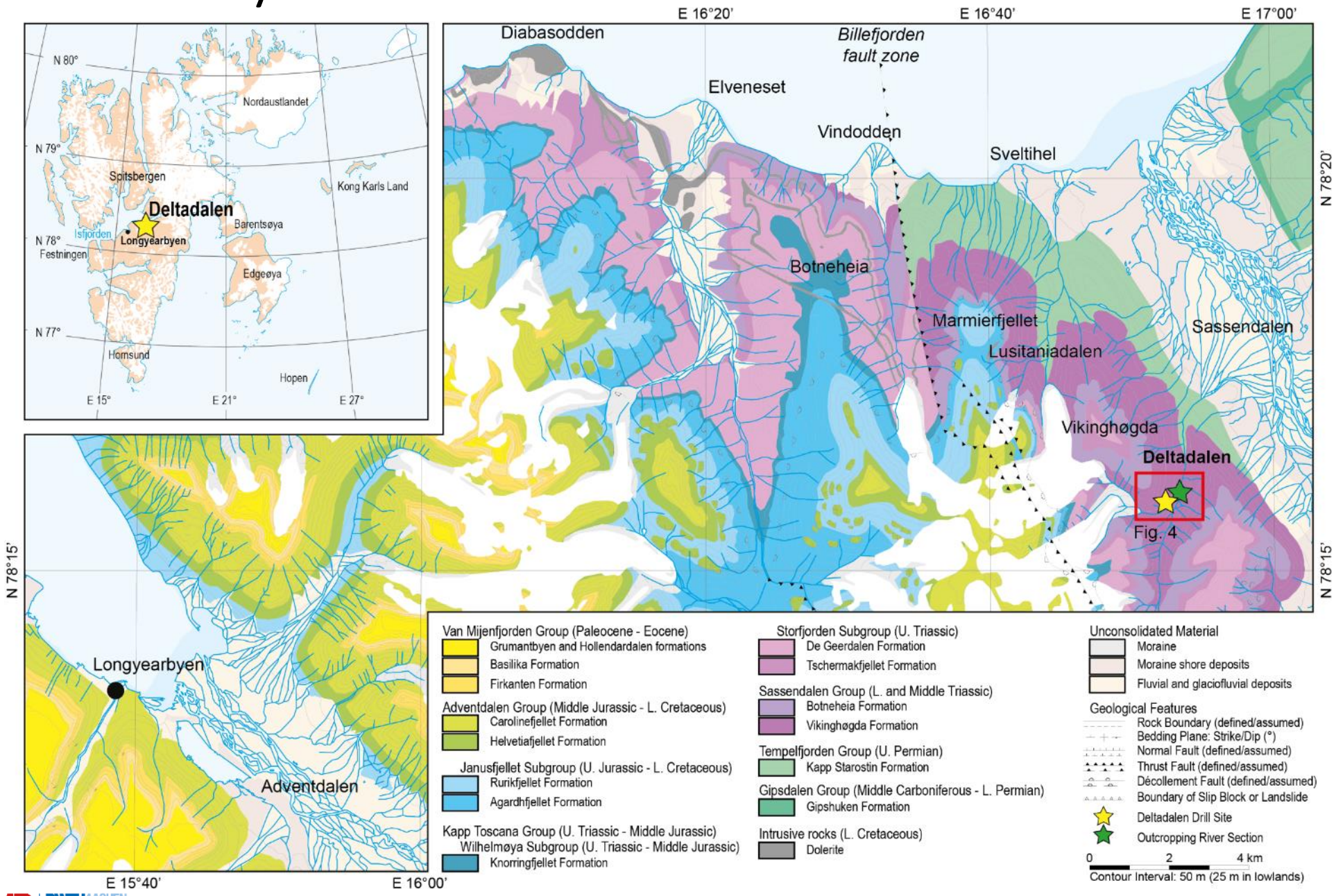
Ogg *et al.* (2016)

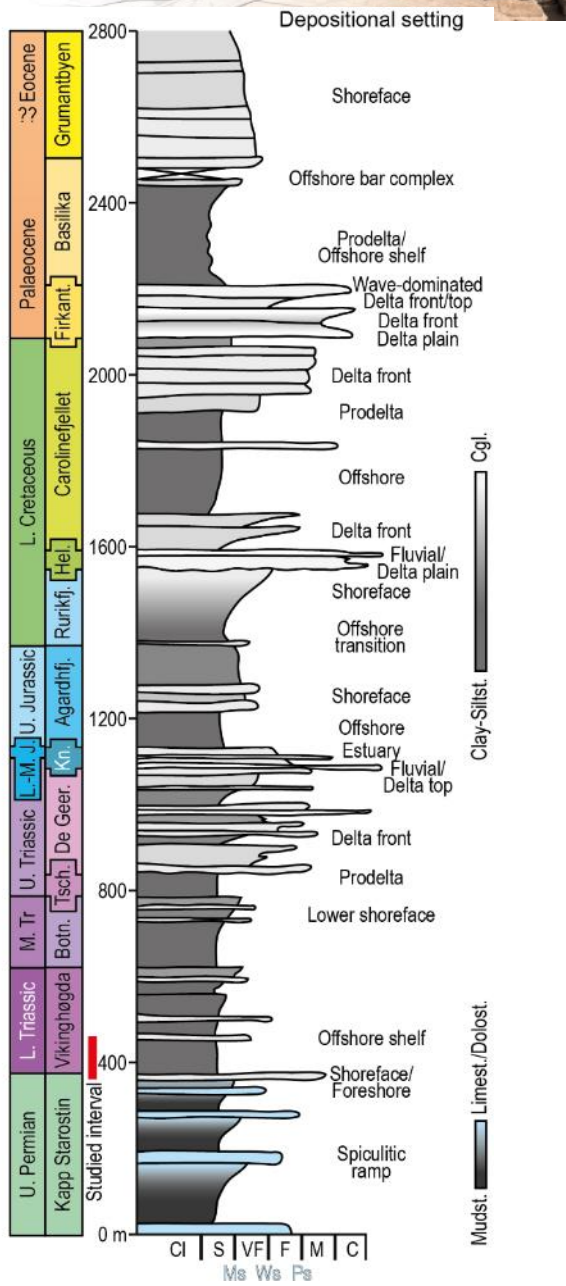


U-Pb dating after Burgess *et al*. (2014),
Photo from Nanjing Institute of Geology and Paleontology

2. Study area

N 80°
N 79°
N 78°
N 77°
E 15°
E 21°
E 27°
Nordaustlandet
Spitsbergen
Kong Karls Land
Deltadalen
Barentsøya
Isfjorden
Longyearbyen
Festningen
Edgeøya
Hornsund
Hopen


E 16°20'
E 16°40'
E 17°00'
N 78°20'
N 78°15'
E 15°40'
E 16°00'
Diabasodden
Billefjorden fault zone
Elveneset
Vindodden
Sveltihel
Botneheia
Marmierfjellet
Lusitaniadalen
Sassendalen
Vikinghøgda
Deltadalen
Fig. 4
Longyearbyen
Adventdalen
Van Mijenfjorden Group (Paleocene - Eocene)
Grumantbyen and Hollendardalen formations
Basilika Formation
Firkanten Formation
Adventdalen Group (Middle Jurassic - L. Cretaceous)
Carolinefjellet Formation
Helvetiafjellet Formation
Janusfjellet Subgroup (U. Jurassic - L. Cretaceous)
Rurikfjellet Formation
Agardhfjellet Formation
Kapp Toscana Group (U. Triassic - Middle Jurassic)
Wilhelmøya Subgroup (U. Triassic - Middle Jurassic)
Knorringfjellet Formation
Storfjorden Subgroup (U. Triassic)
De Geerdalen Formation
Tschermakfjellet Formation
Sassendalen Group (L. and Middle Triassic)
Botneheia Formation
Vikinghøgda Formation
Tempelfjorden Group (U. Permian)
Kapp Starostin Formation
Gipsdalen Group (Middle Carboniferous - L. Permian)
Gipshuken Formation
Intrusive rocks (L. Cretaceous)
Dolerite
Unconsolidated Material
Moraine
Moraine shore deposits
Fluvial and glaciofluvial deposits
Geological Features
Rock Boundary (defined/assumed)
Bedding Plane: Strike/Dip (°)
Normal Fault (defined/assumed)
Thrust Fault (defined/assumed)
Décollement Fault (defined/assumed)
Boundary of Slip Block or Landslide
Deltadalen Drill Site
Outcropping River Section
0 2 4 km
Contour Interval: 50 m (25 m in lowlands)

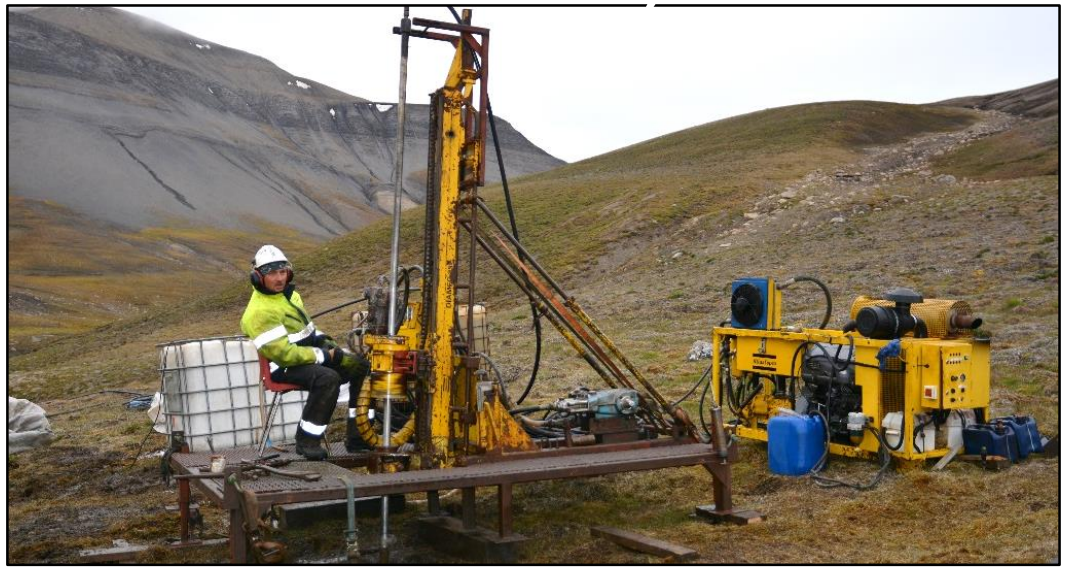

Depositional setting
Palaeocene
?? Eocene
Grumantbyen
Basilika
Firkant.
L. Cretaceous
Carolinefjellet
Hel.
Rurikfj.
U. Jurassic
Agardhfj.
L.-M. J.
Kn.
U. Triassic
De Geer.
M. Tr
Tsch.
Botn.
L. Triassic
Vikinghøgda
U. Permian
Kapp Starostin
Studied interval
2800
2400
2000
1600
1200
800
400
0 m
Shoreface
Offshore bar complex
Prodelta/ Offshore shelf
Wave-dominated Delta front/top
Delta front
Delta plain
Delta front
Prodelta
Offshore
Delta front
Fluvial/ Delta plain
Shoreface
Offshore transition
Shoreface
Offshore
Estuary
Fluvial/ Delta top
Delta front
Prodelta
Lower shoreface
Offshore shelf
Shoreface/ Foreshore
Spiculitic ramp
Cgl.
Clay-Siltst.
Limest./Dolost.
Mudst.
Cl S VF F M C
Ms Ws Ps

1. Geological setting

Vikinghøgda Fm. – Offshore ramp setting

Kapp Starostin Fm. – Shoreface setting ?

2. Study area



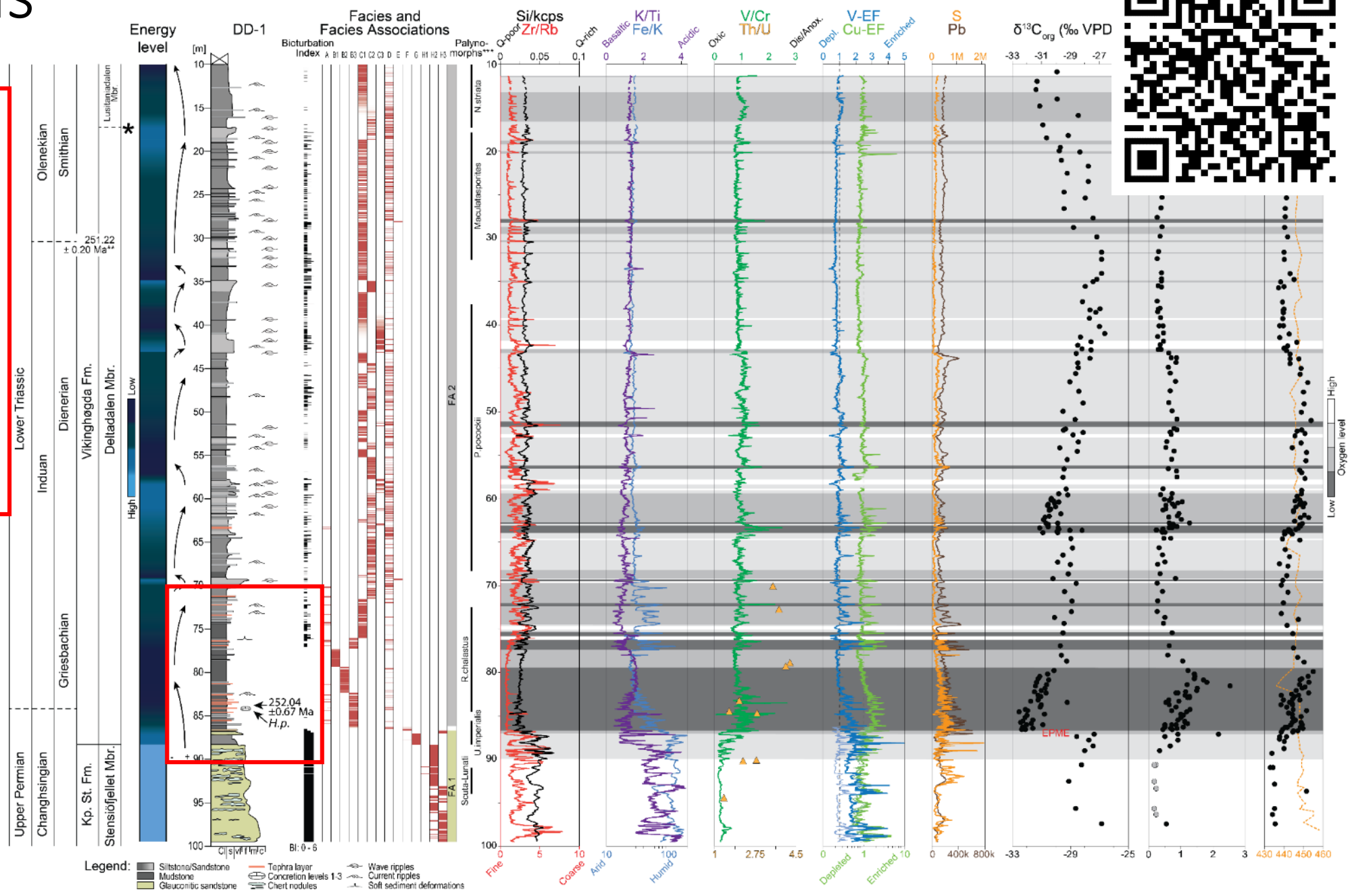
Deltadalen Drilling:

- Distance from major faults
- Proximity to Vikinghøgda Fm. type section (Mørk *et al.*, 1999)
- Two 100 m deep boreholes (90 m continuous cores)

3. Methods

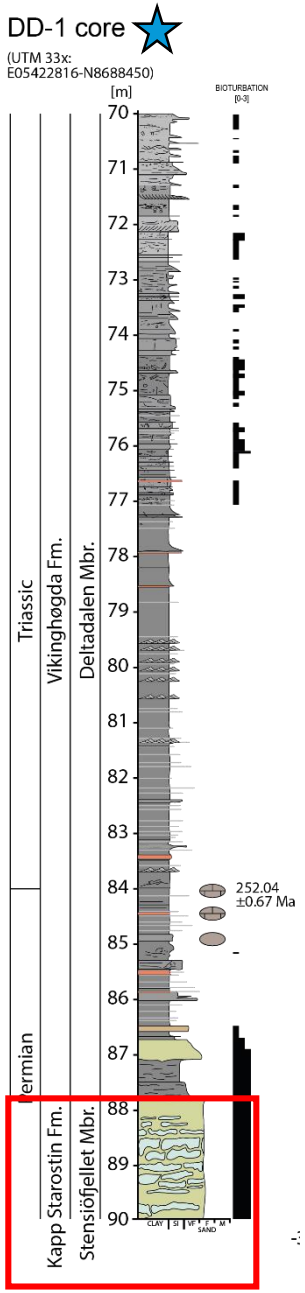
- Highres logging
- XRF-scan (selected ratios)
- Geochem.
- Zircon dating
- Micropal
- Mineralogy
- Palynofacies

- Extra data:
  - Hyperspectr.



4. Deltadalen

4.0. Sedimentology



- Kapp Starostin: f-c sand, bioclasts, chert patches, occasional PPS, very bioturbated

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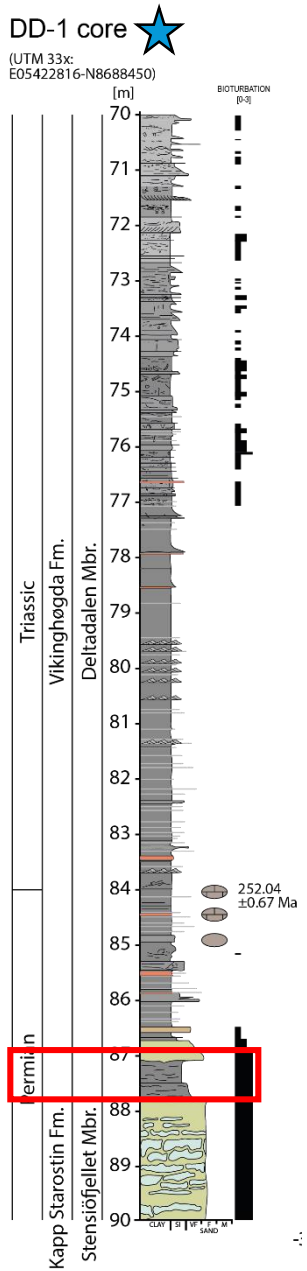
EGU2022, GD8.2

4. Deltadalen

4.0. Sedimentology



- Base Vikinghøgda Fm. = rapid finning-up, vf-sand to silt, BUT very bioturbated: BI = 5, 11 ichnotaxa
- Kapp Starostin: f-c sand, bioclasts, chert patches, occasional PPS, very bioturbated

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4. Deltadalen

4.0. Sedimentology

- Completely dead?
- Tephra beds and dark laminated mudstone (Mordor)
- Rapid but selective disappearance of bioturbation BI = 5 to 0; 5 to 2 ichnotaxa
- Base Vikinghøgda Fm. = rapid finning-up, vf-sand to silt, BUT very bioturbated: BI = 5, 11 ichnotaxa
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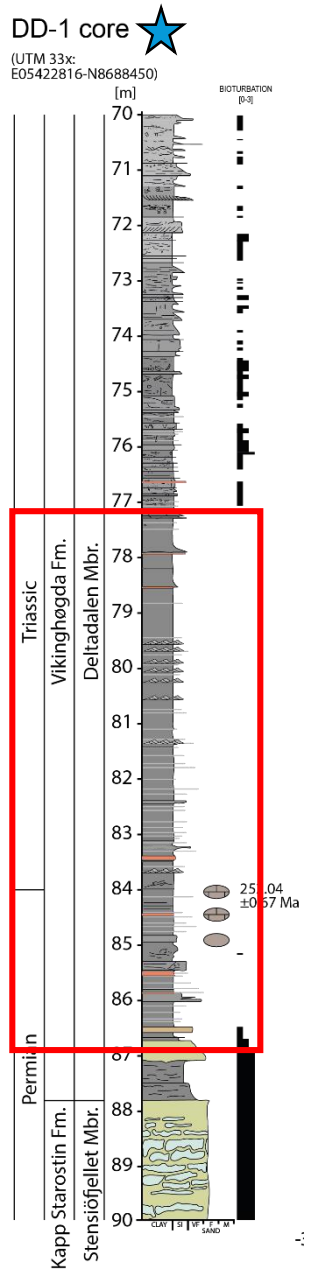

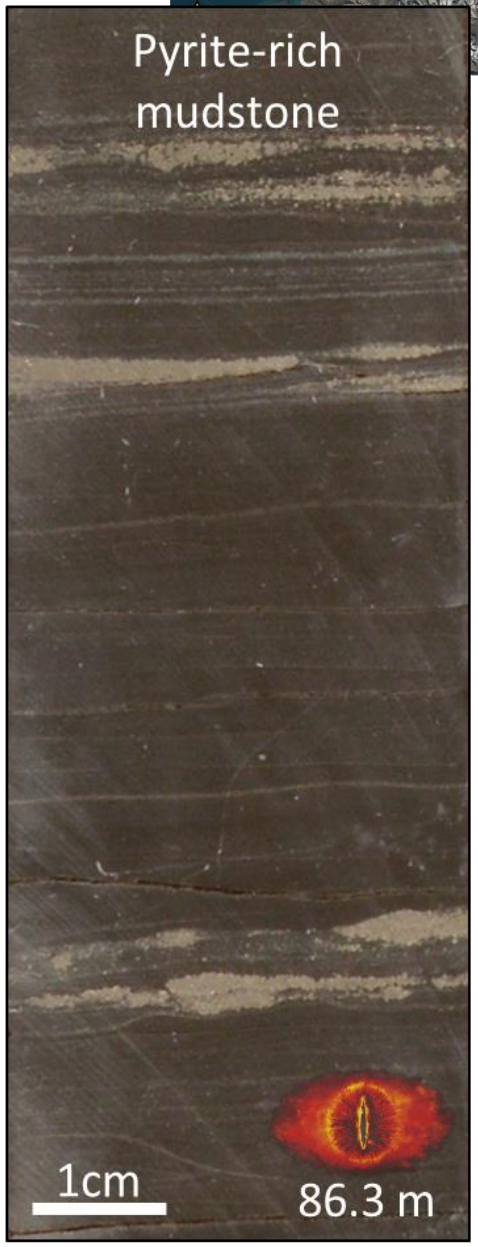

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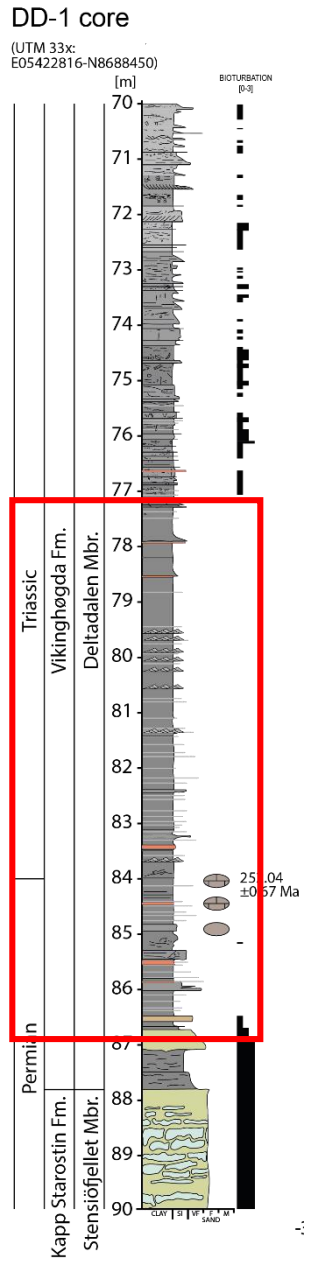
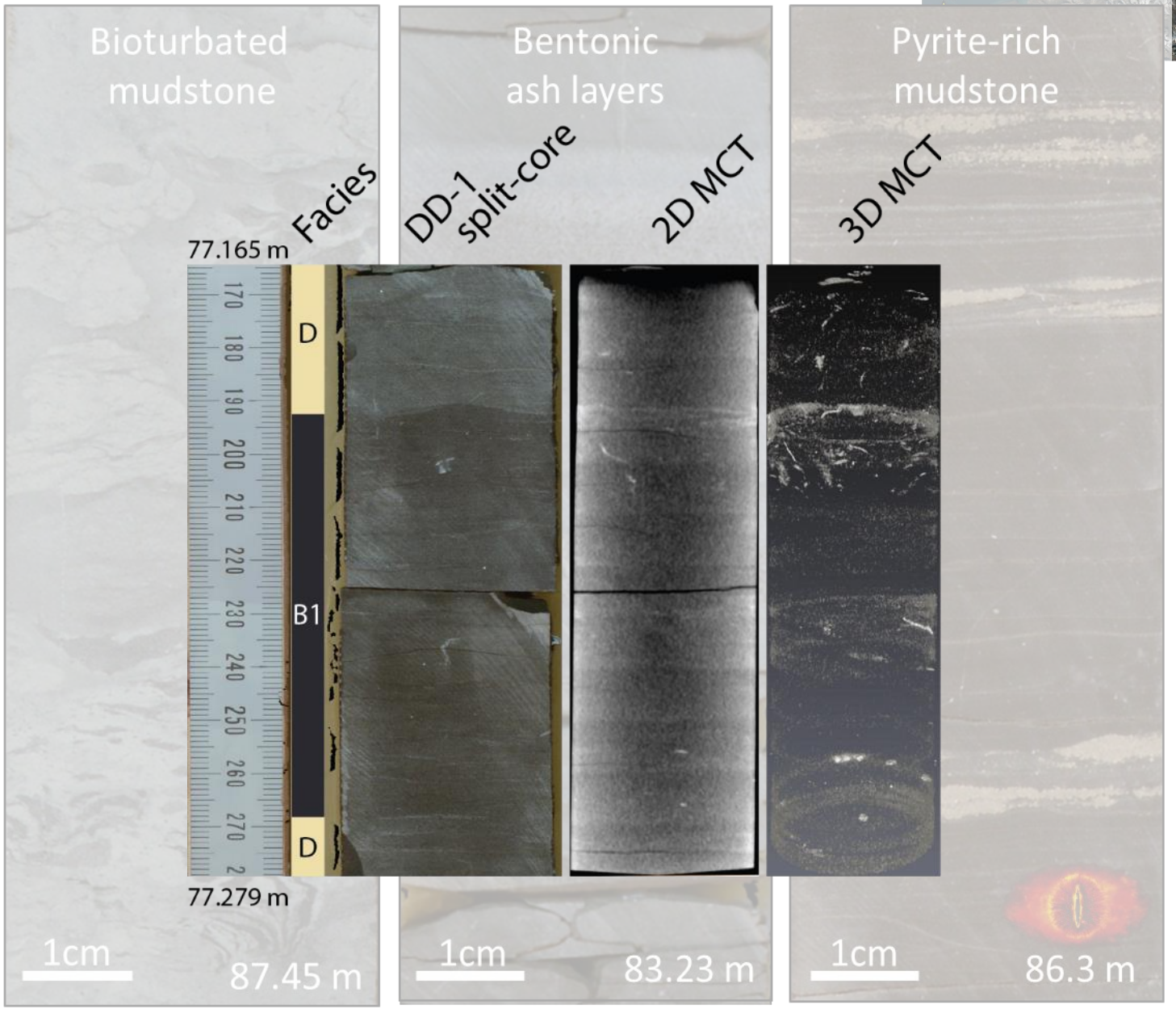




4. Deltadalen

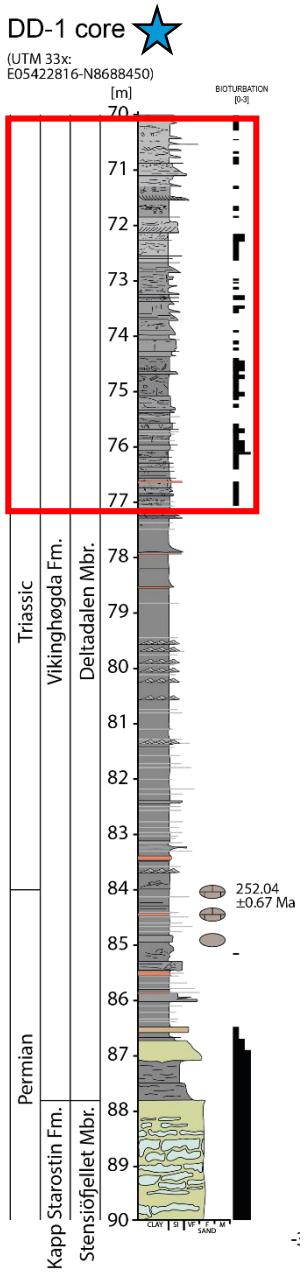
4.0. Sedimentology

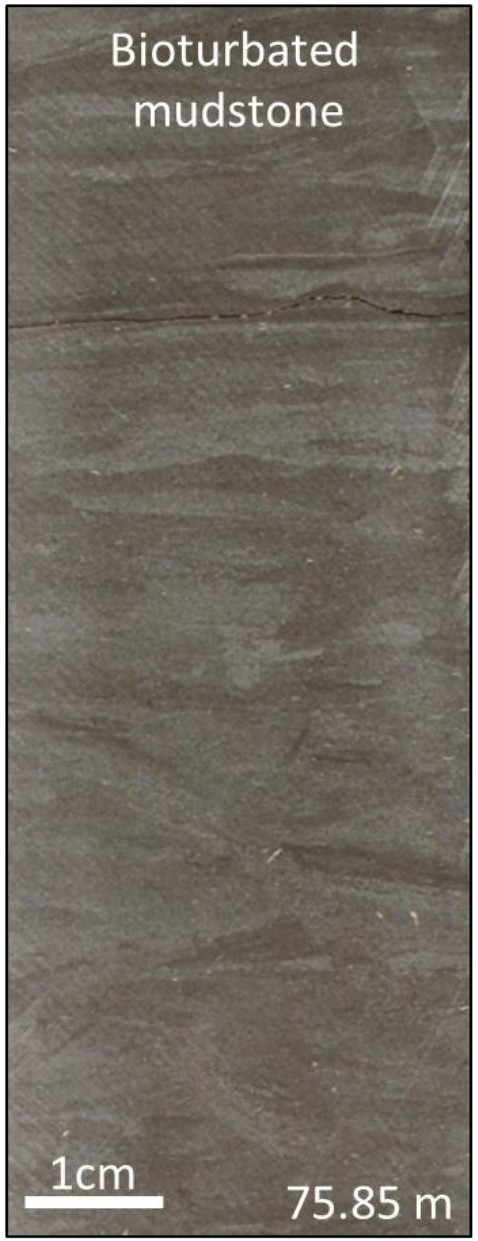
- Coarsening up, mudstone to vf sand, with occasional ripples and event beds (hyperpicnites/turbidites, HCS-beds)
- Return of macroscopic bioturbations: BI = 0 to 5; 5 to 10 ichnotaxa

- Completely dead?
- Tephra beds and dark laminated mudstone (Mordor)
- Rapid but selective disappearance of bioturbation BI = 5 to 0; 5 to 2 ichnotaxa

- Base Vikinghøgda Fm. = rapid finning-up, vf-sand to silt, BUT very bioturbated: BI = 5, 11 ichnotaxa

- Kapp Starostin: f-c sand, bioclasts, chert patches, occasional PPS, very bioturbated





4. Deltadalen

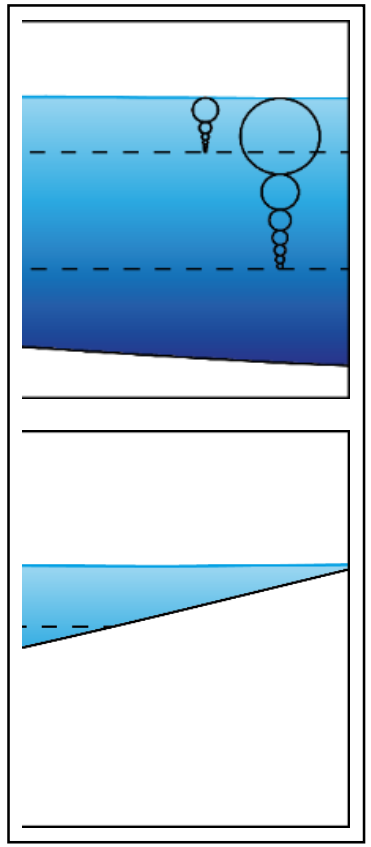
Deltadalen

Basin reorganisation

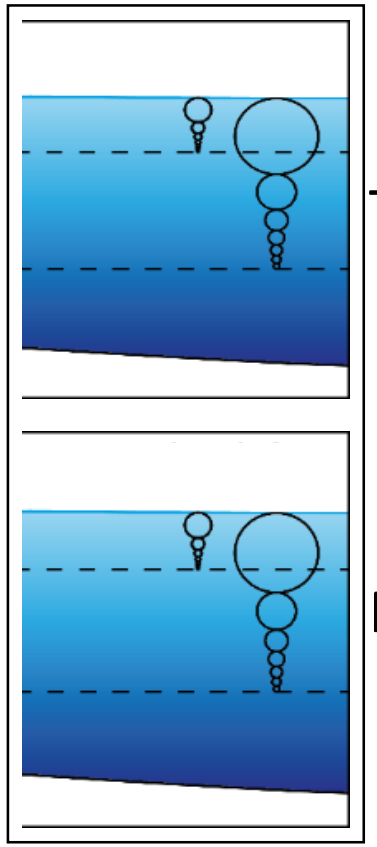
Environmental change

Triassic = Deep

Permian = Shallow

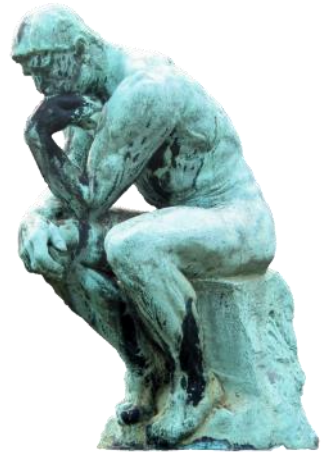


Or?



Triassic = Deep

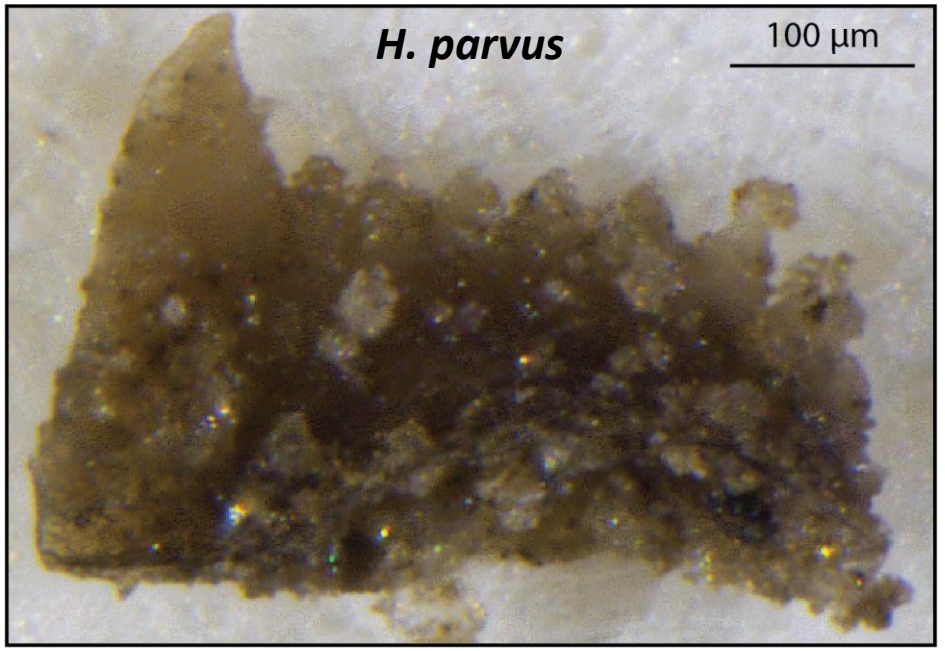
Permian = Deep

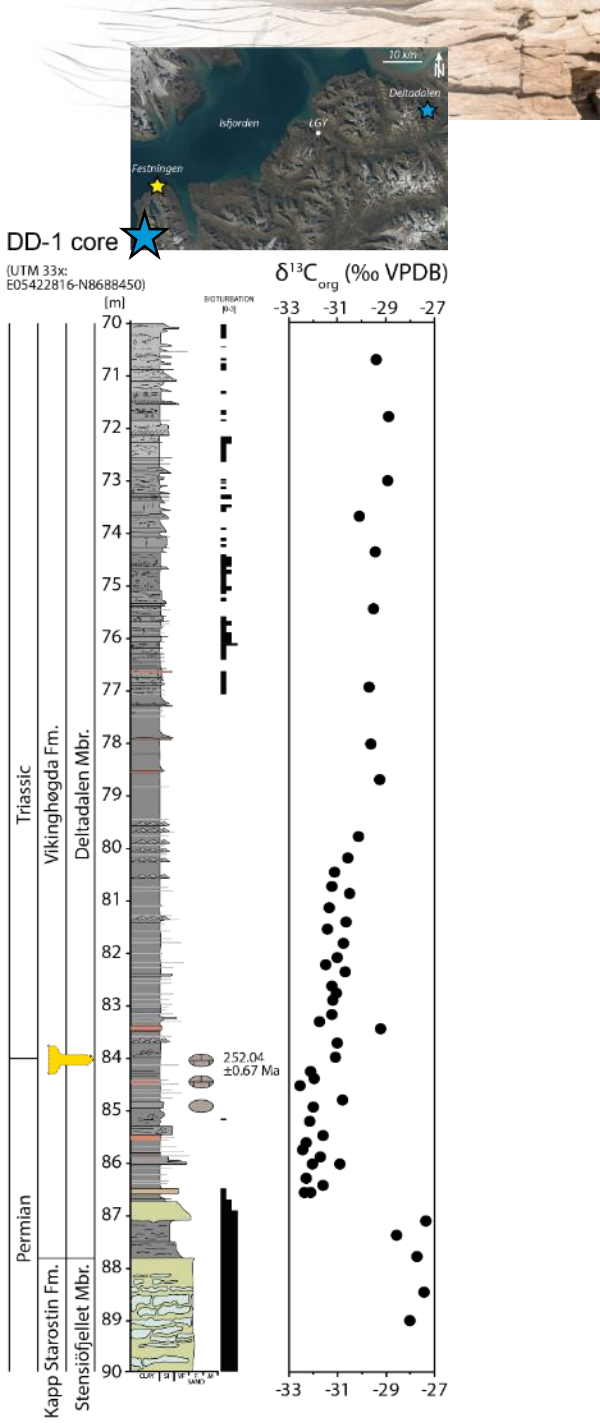


4. Deltadalen

4.1. Micropalaeontology and age

- ***H. parvus***: 84.00 mbs
- 252.04 ± 0.67 Ma





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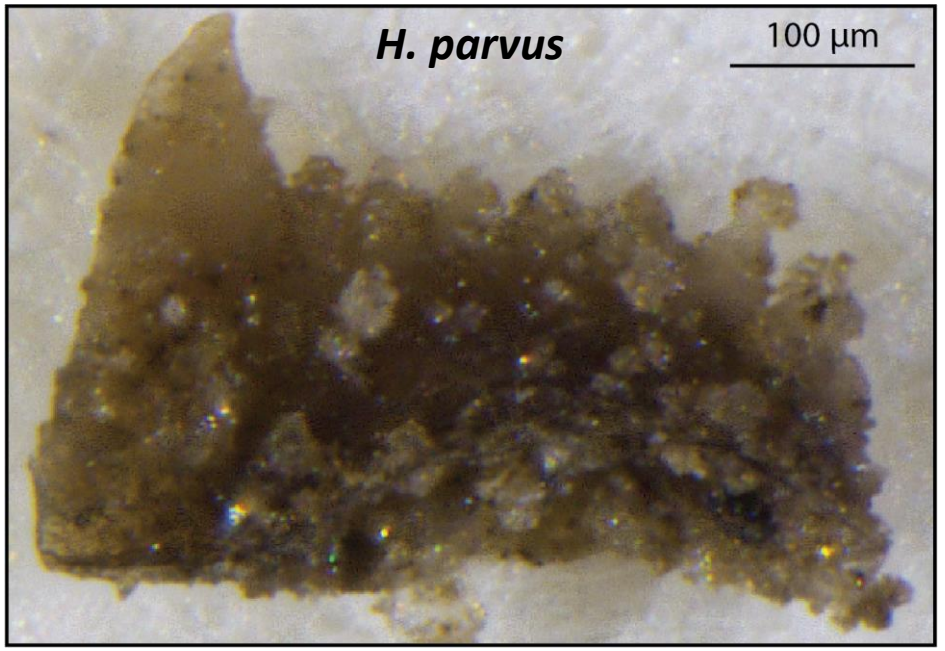
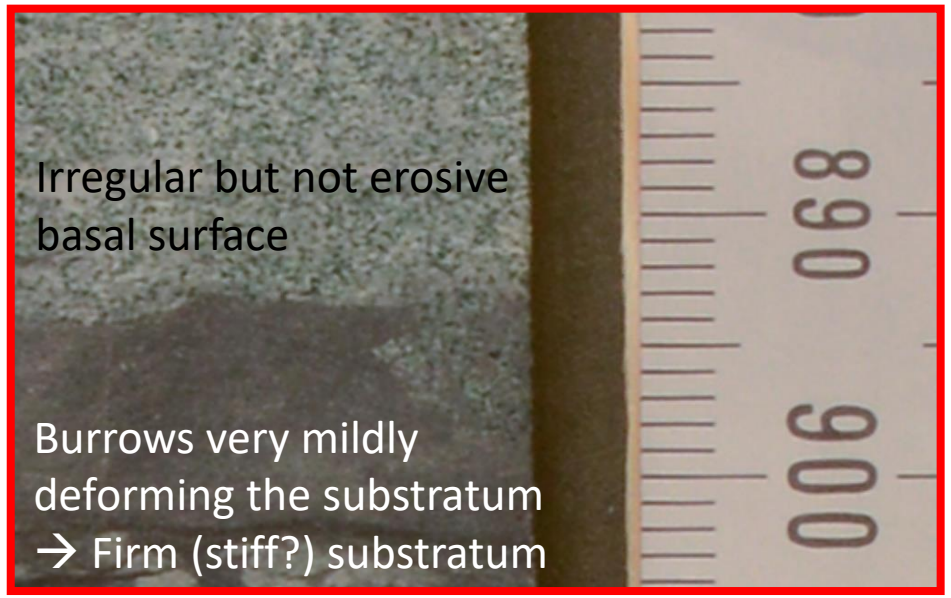
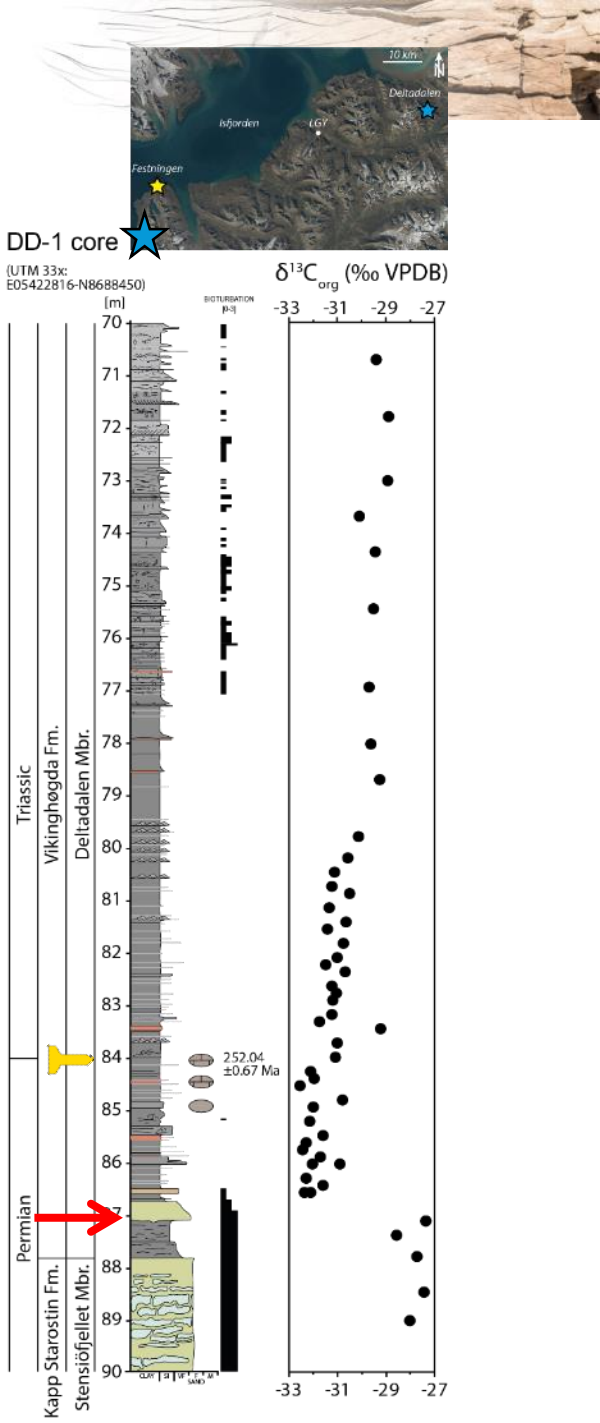
4.2. $\delta^{13}C_{org}$ – End-Permian ME

- Nearly 5 ‰ drop ≠ Formation boundary
- Condensed section







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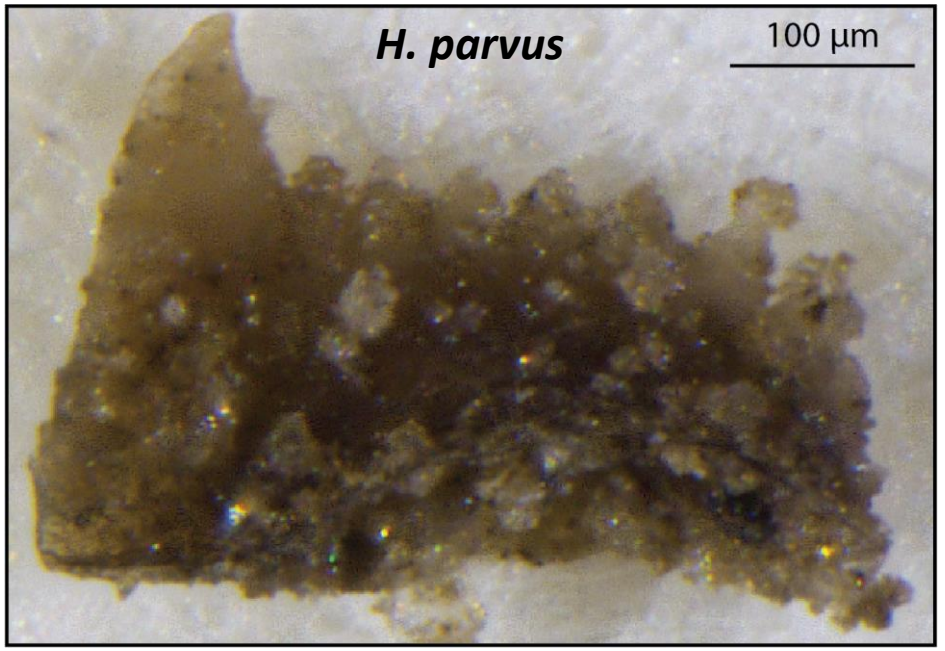
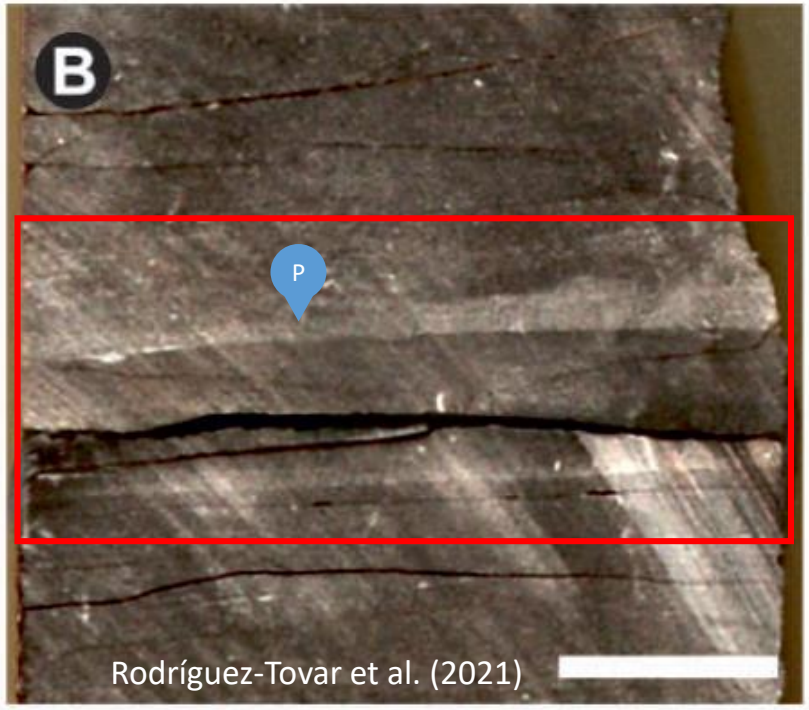
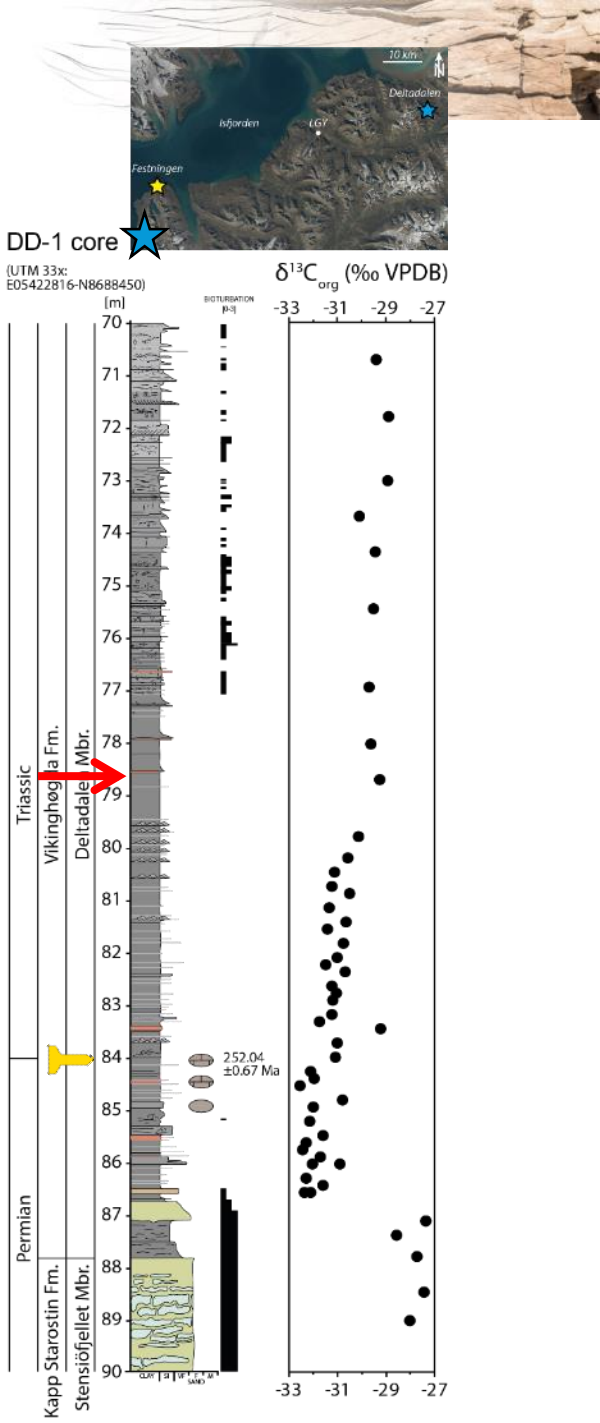
4.3. Ichnology

- Progressive and selective disappearance
- “Pulses” of *Planolites* and *Phycosiphon* (P) → short-lived episodes of increased oxygen during “Mordor” interval
- <200 kyr to go back to pre-ME levels







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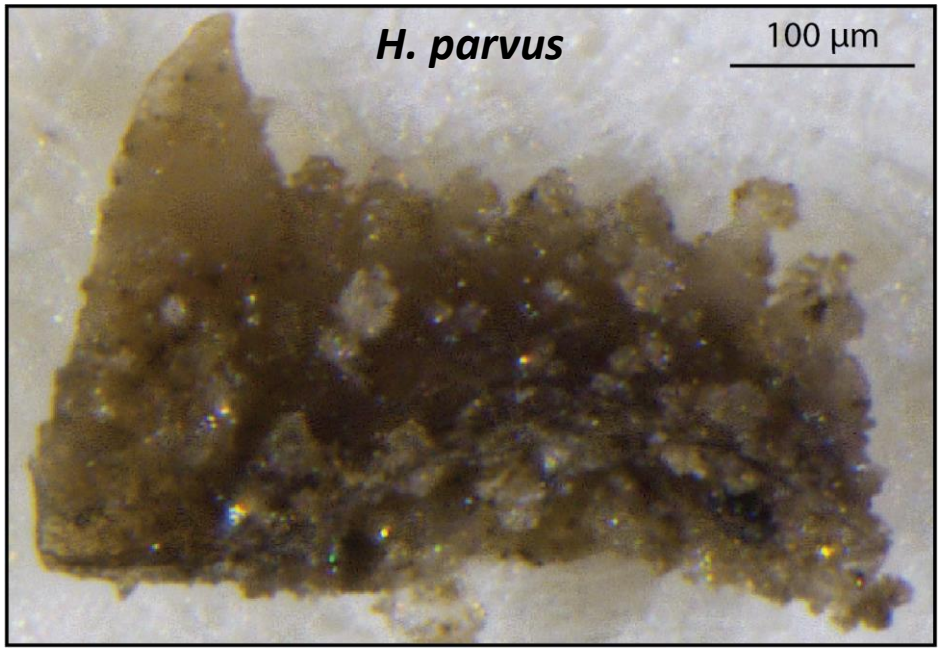
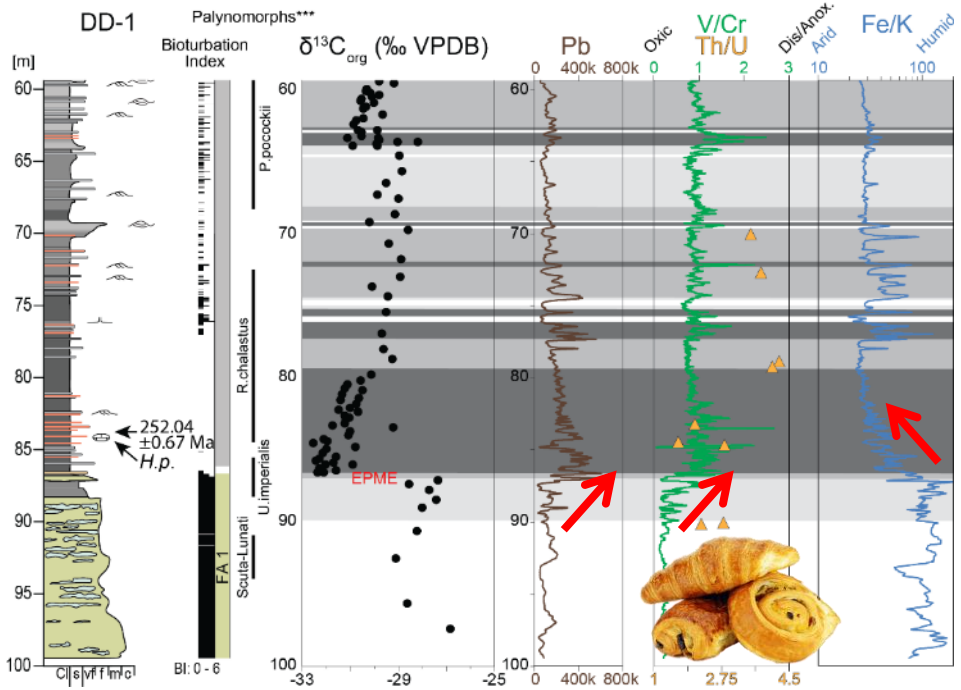
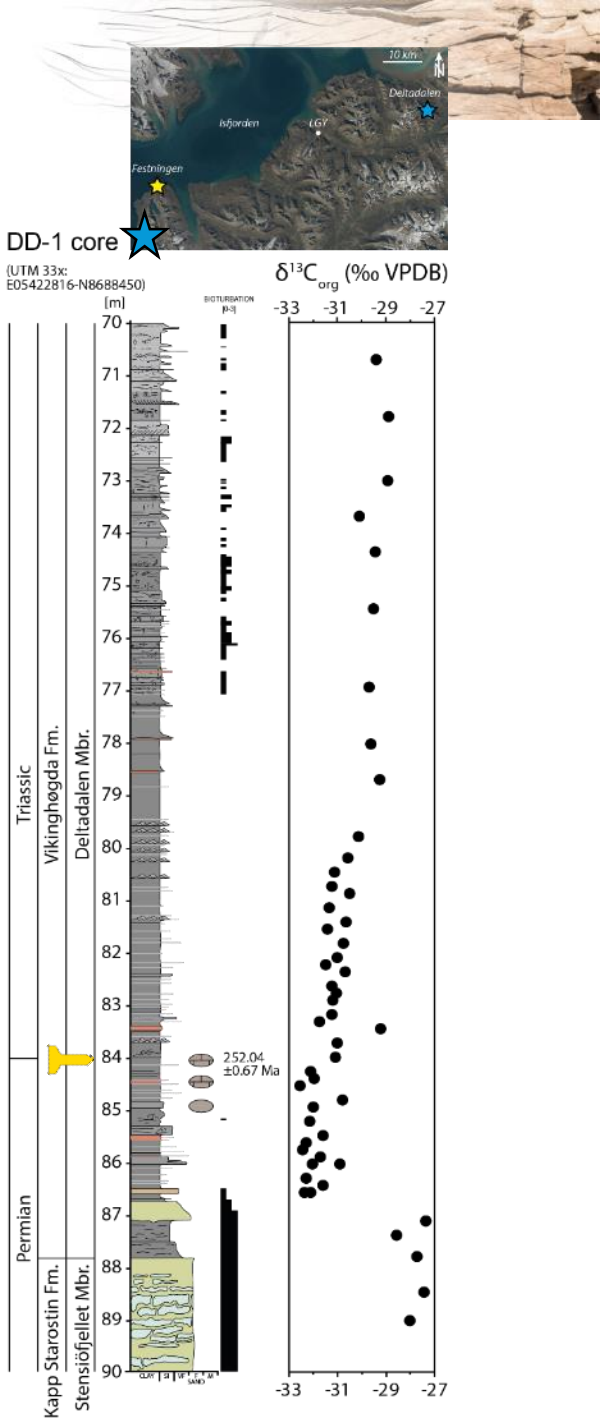
4.4. Geochemistry

- Tephra beds and High Pb → Volcanic activity, coal fire
- Increasing V/Cr and Th/U → dys-/anoxia
- Drop in Fe/K → more arid





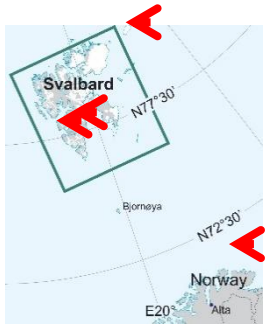


5. Summary

Comparing to the Festningen section and other sections around Svalbard

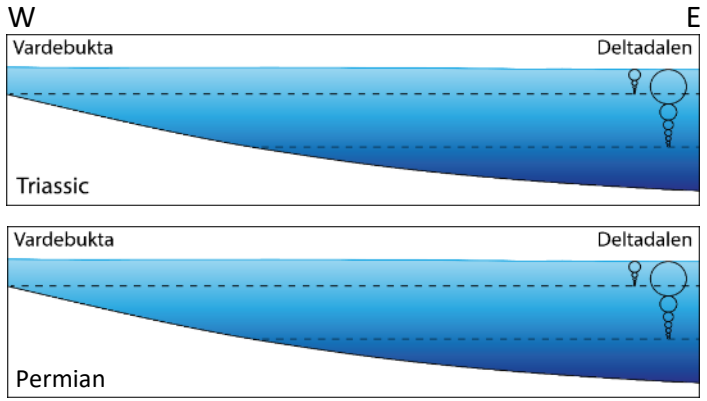
- Ongoing work! → not a lacuna/hiatus
- Nearly 7 ‰, step drop
- Drop starts @ Formation boundary
- Formation boundary = loss of bioturbation (?)

→ Major facies change at Deltadalen occurring before major facies change at Festningen?



Open Questions

- Correlation to Barents S.?
- Correlation up north?
- Is the Permian glauconitic sandstone really shallow-marine?



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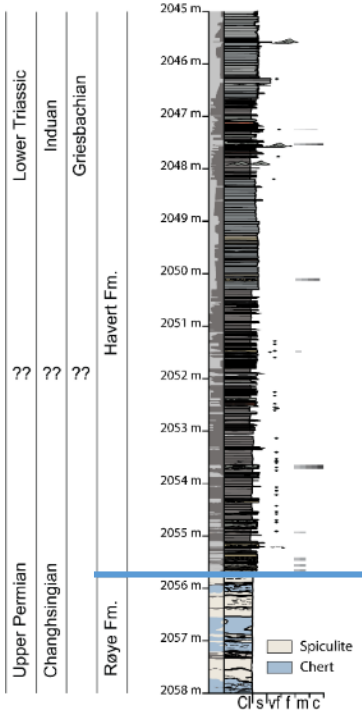
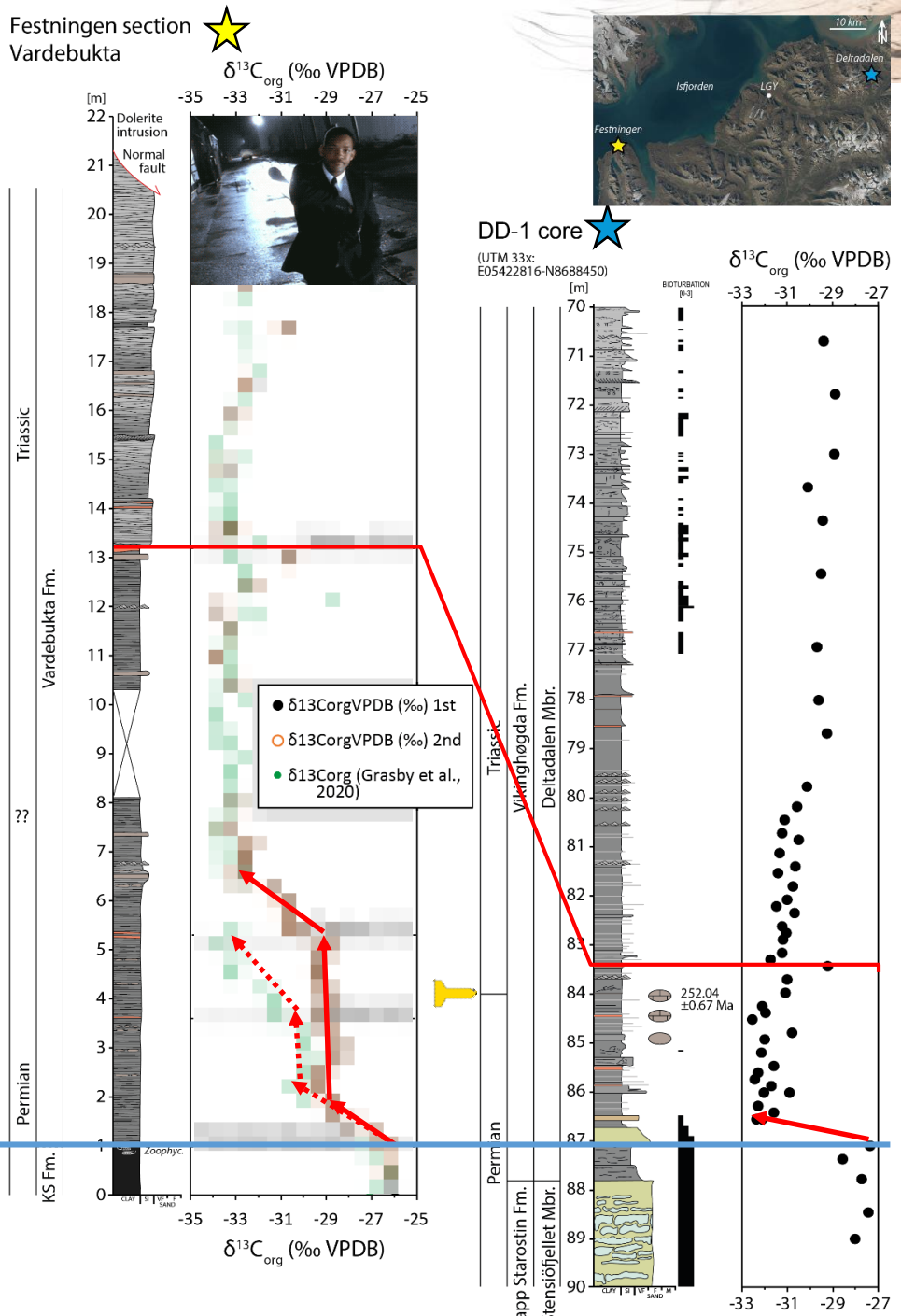
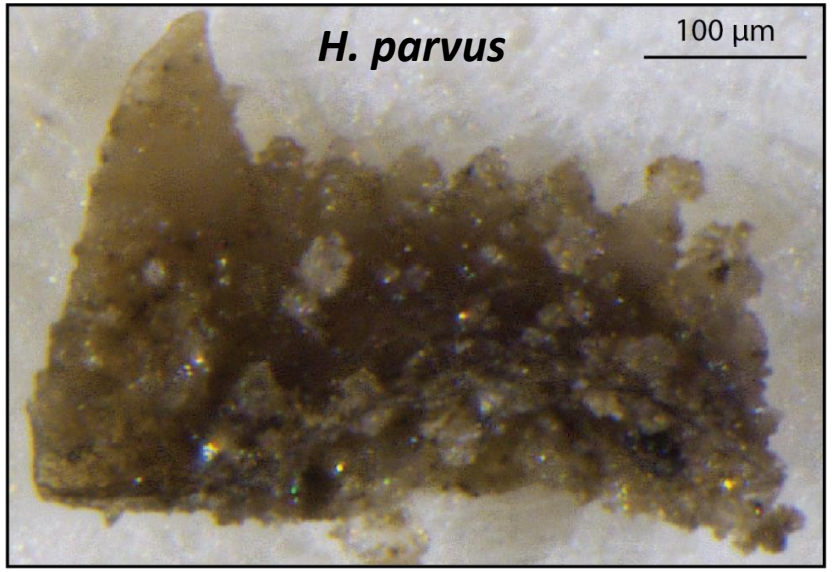
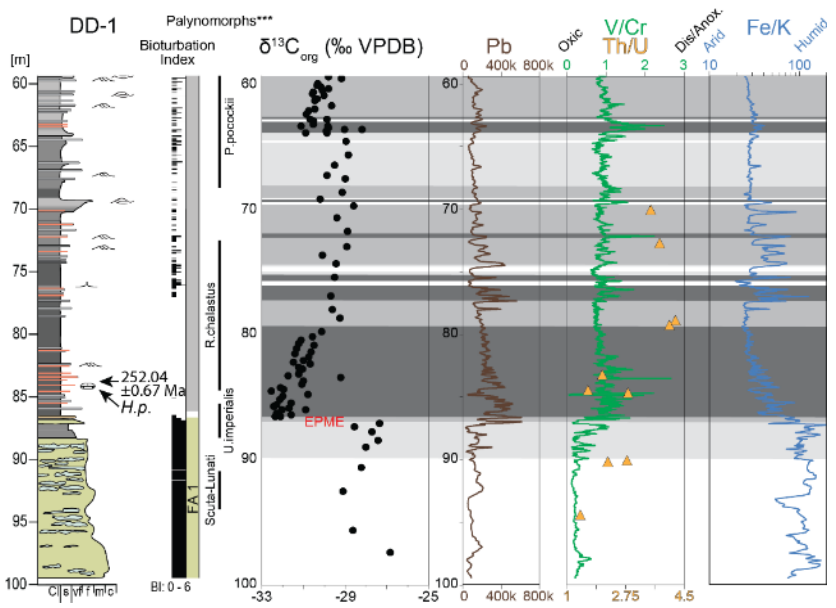


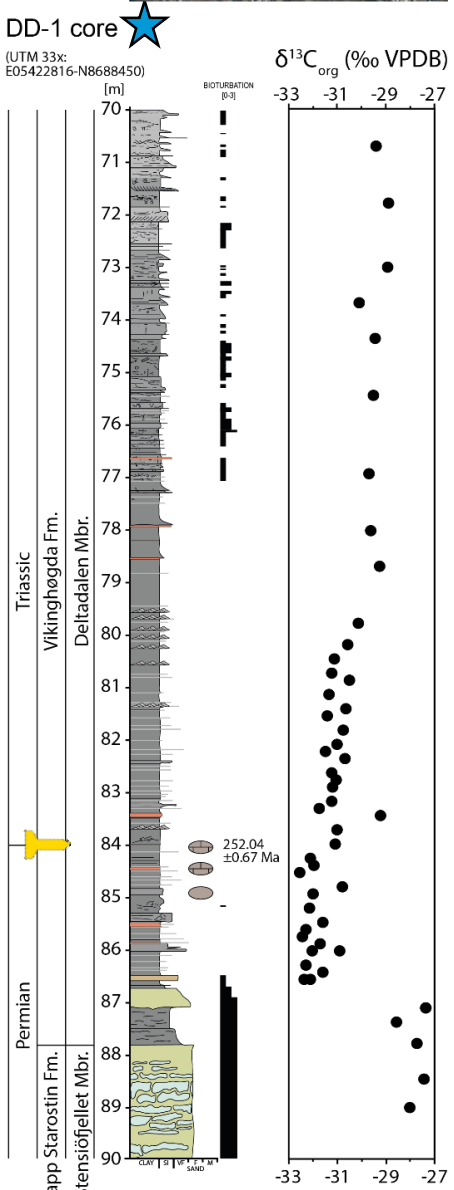


5. Summary

- Good ash date + *H. parvus*
- EPME, condensed section
- Strong dys-/anoxia due to nutrient influx (Schobben *et al*., 2020)
- Change towards more arid climate
- Rapid Life recovery (Rodríguez-Tovar *et al*., 2021)







Thanks for your attention!

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