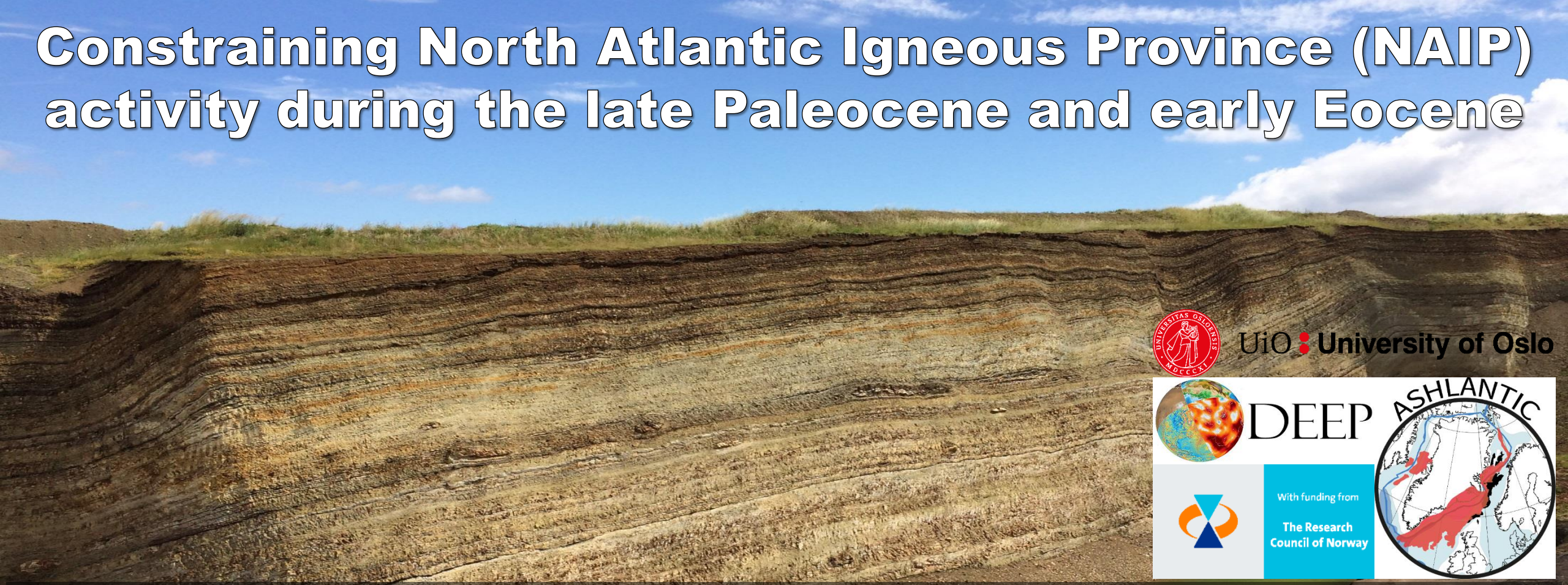
Constraining North Atlantic Igneous Province (NAIP) activity during the late Paleocene and early Eocene



UiO : University of Oslo

DEEP

ASHLANTIC

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Morgan Jones, Ella Stokke, Lars Augland, Sverre Planke, Henrik Svensen (University of Oslo)
Philip Pogge von Strandmann, Emma Liu (University College London)
Tamsin Mather, Jack Longmann (University of Oxford)
Alan Rooney (Yale University)
Jessica Whiteside (University of Southampton)
Jessica Tierney (University of Arizona)
Christian Tegner (Aarhus University)
Bo P. Schultz (Fur Museum, Denmark)

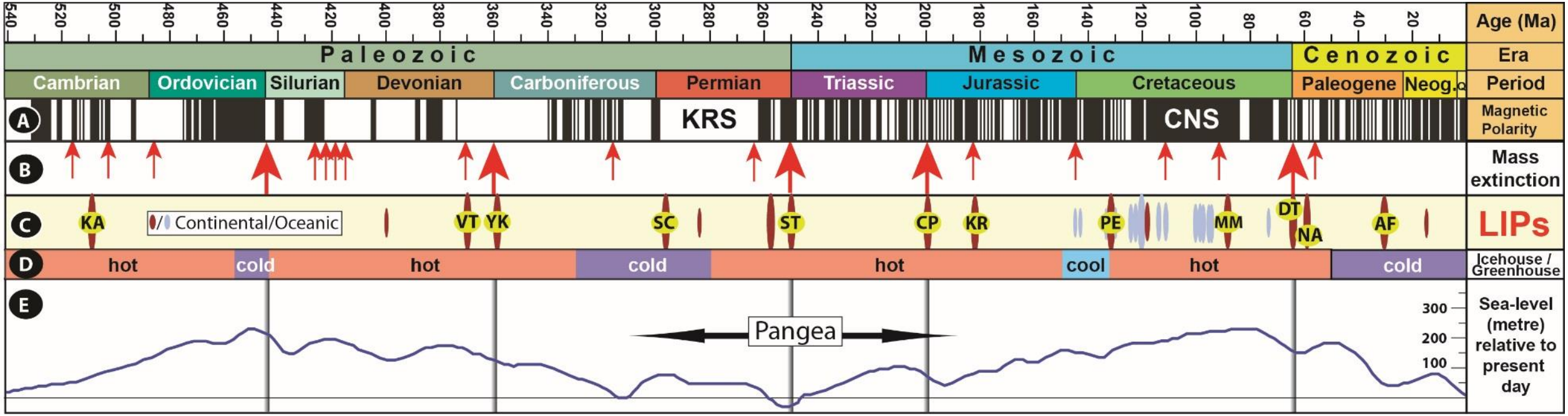
Covid-19 Limitations

Sadly, some of the results we hoped to present cannot be shown as the papers are still in review or in preparation.

Instead, we will highlight the ongoing work of the project ***Ashlantic***.

This is also a call for potential collaboration. We are in the process of applying for funding for **ICDP** and **IODP** drilling projects in Denmark and the Norwegian margin. If successful, we hope to have core material covering the mid-Paleocene to Oligocene. If this is of potential interest, please get in contact.

LIPs and Climate Change



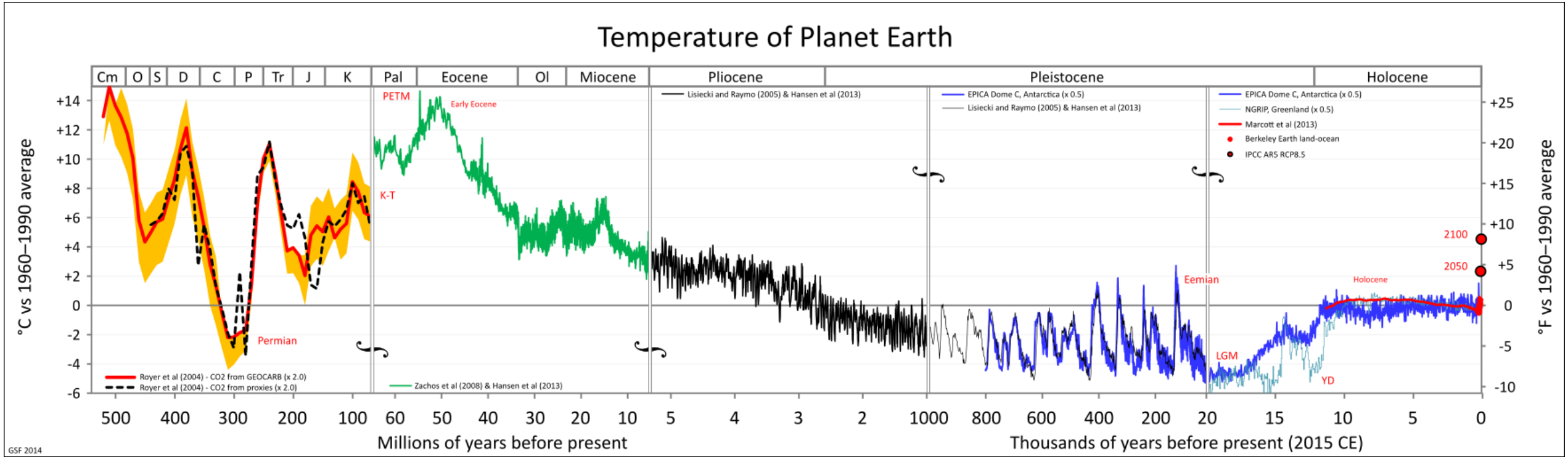
(Jones et al, 2016)

There is a temporal correlation between Large Igneous Provinces (LIPs) and mass extinctions

This suggests a possible causal relationship

Therefore, we need to understand how LIPs can potentially drive rapid climate change

The Paleocene-Eocene

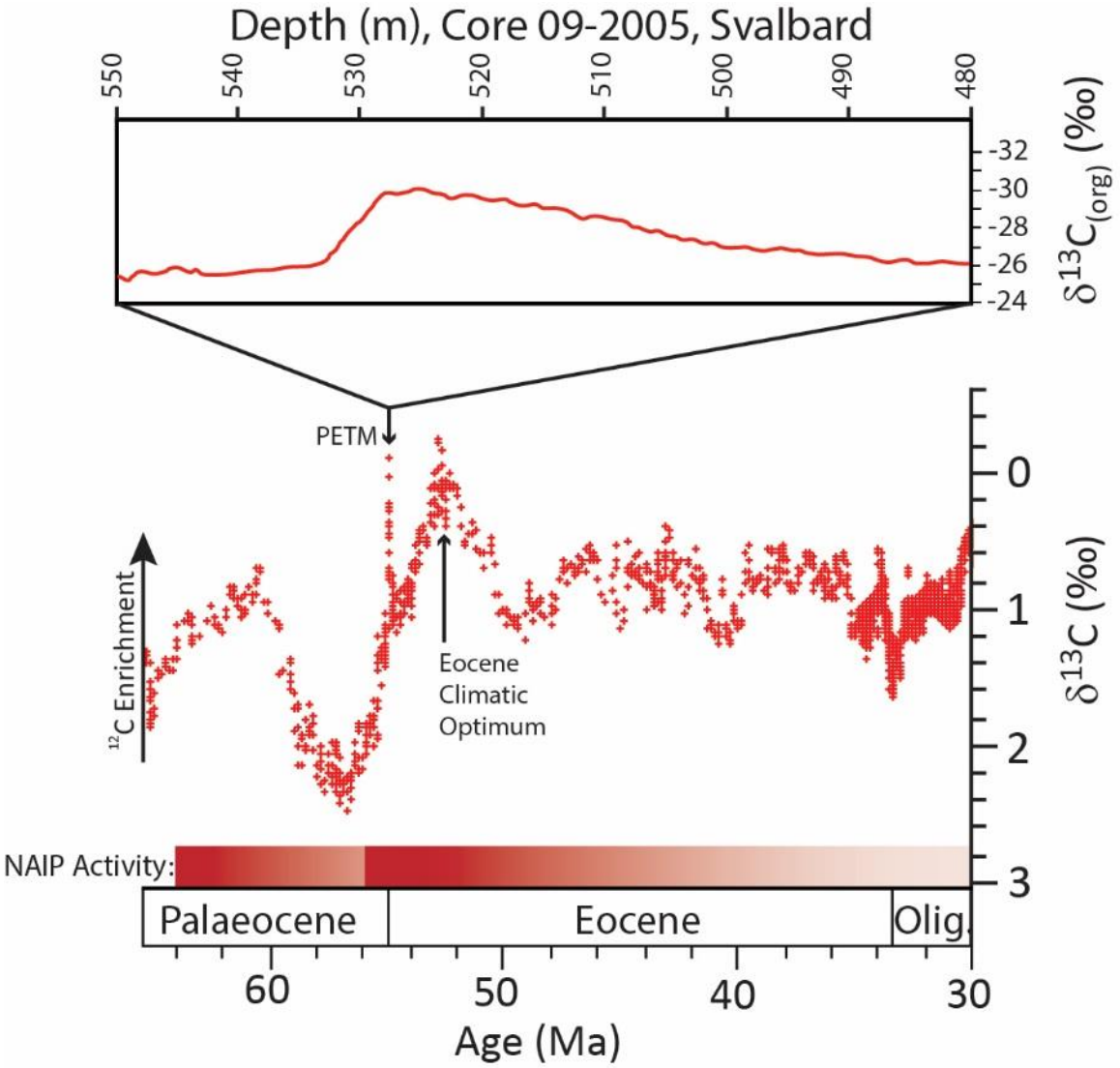


(by Glen Fergus)

The Warmest Surface Temperatures in the last 60 Ma

Largest hyperthermal event is called the
Palaeocene-Eocene Thermal Maximum (PETM)

The PETM



(Zachos et al, 2005, Charles et al, 2011)

Global negative carbon isotope excursion (3-5‰)

Rapid and sustained warming
4-6 °C globally, locally >10 °C

CO_2 Degassing Estimates
Warming requires two doublings of CO_2 in climate models

Rough estimates:
7000-10000 Gt C

North Atlantic Igneous Province

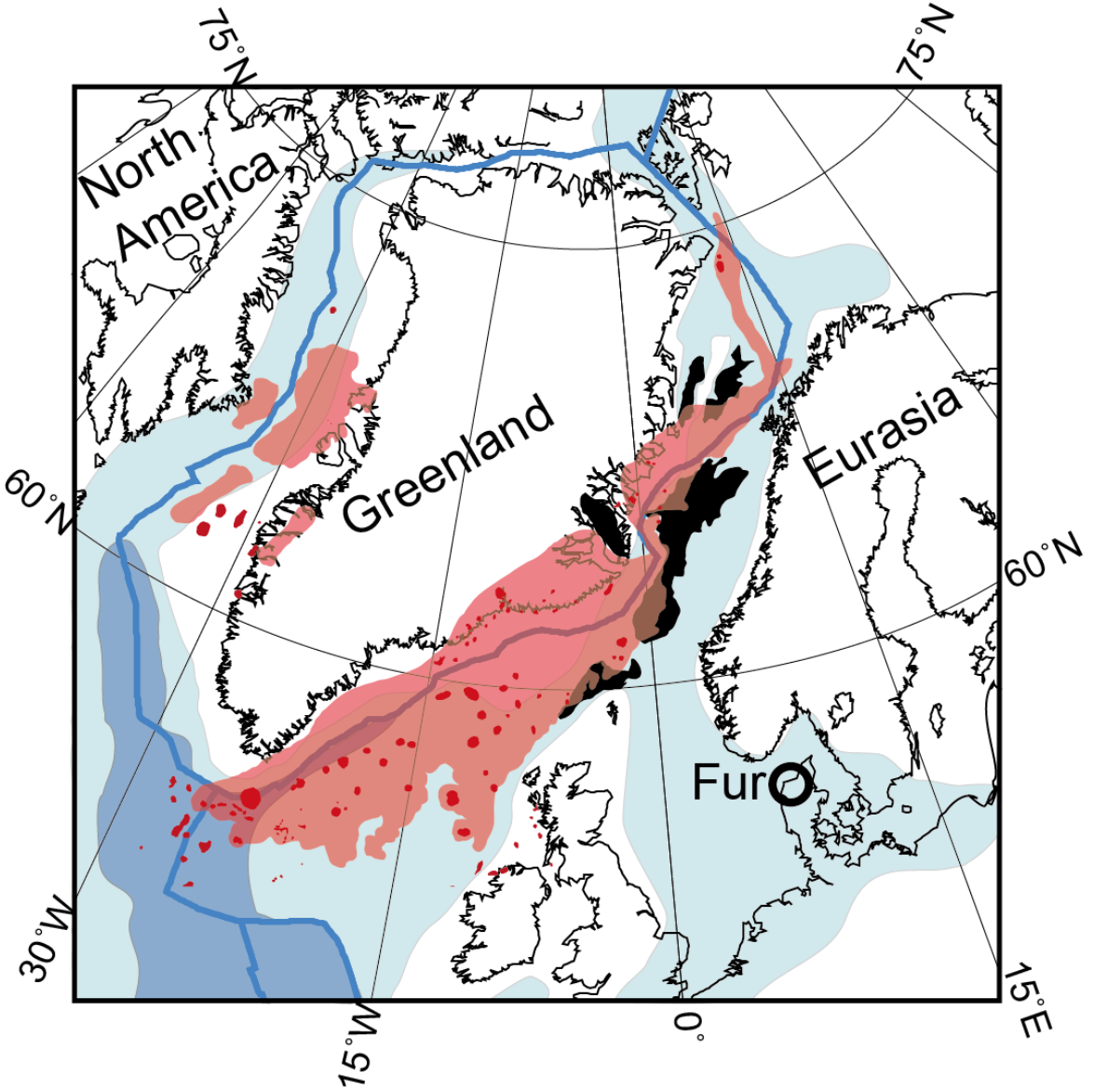
Closely associated with the break-up of the North Atlantic

6-10 x 10^6 km^3 magma emplaced

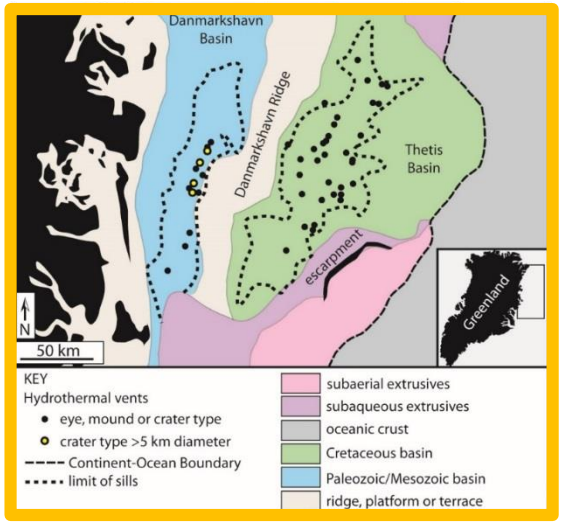
~80 of volume emplaced between 56-54 Ma

Thick lava flows, large intrusions, central complexes, tephra layers

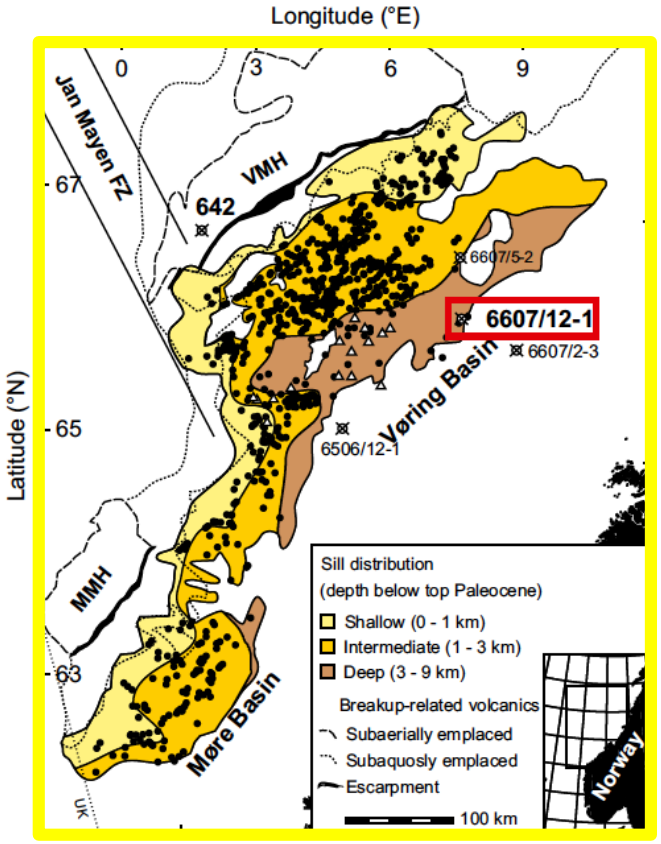
Explosive eruptions are among the largest recorded



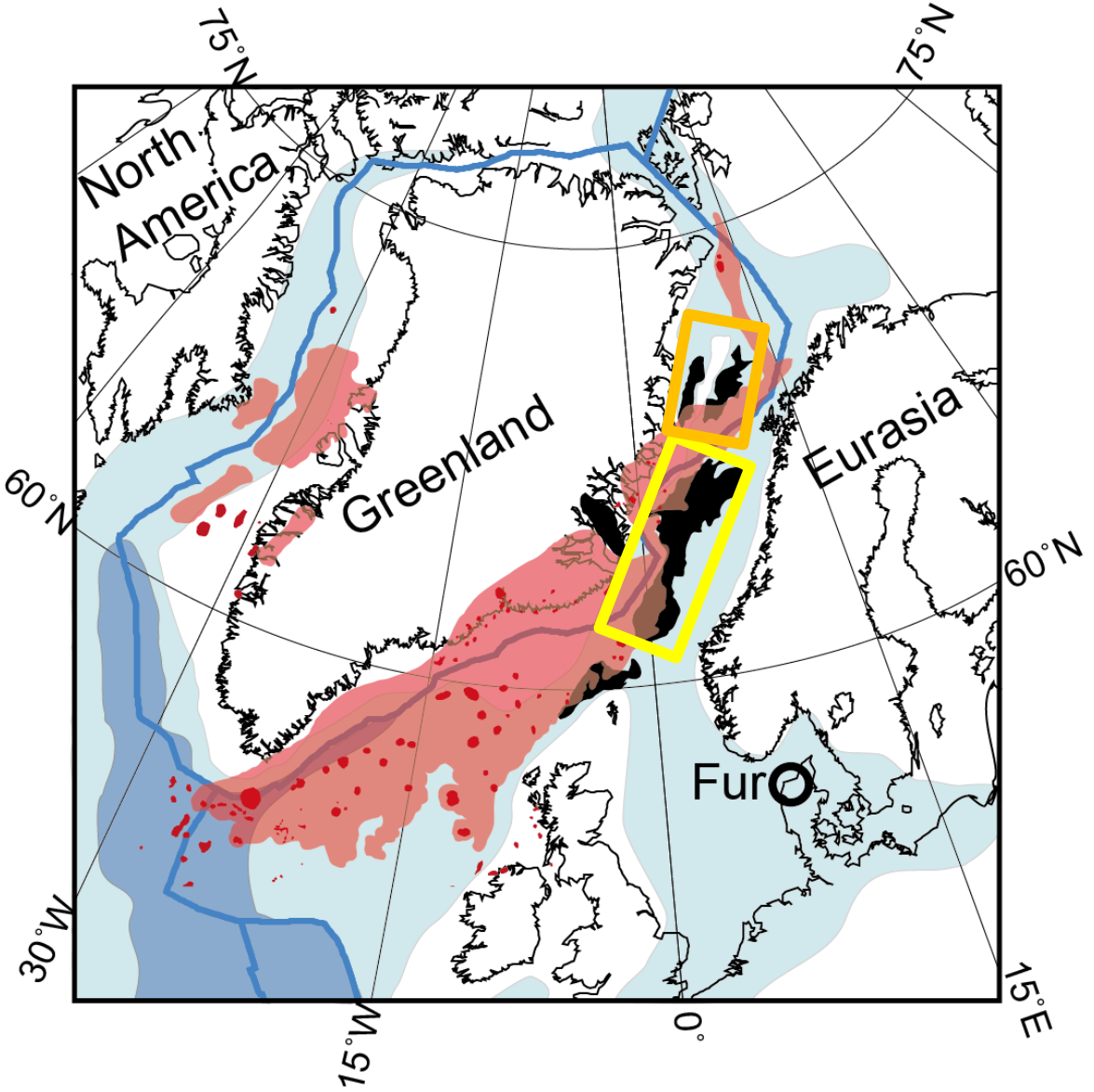
NAIP Activity - Intrusions



Reynolds et al. (2017)

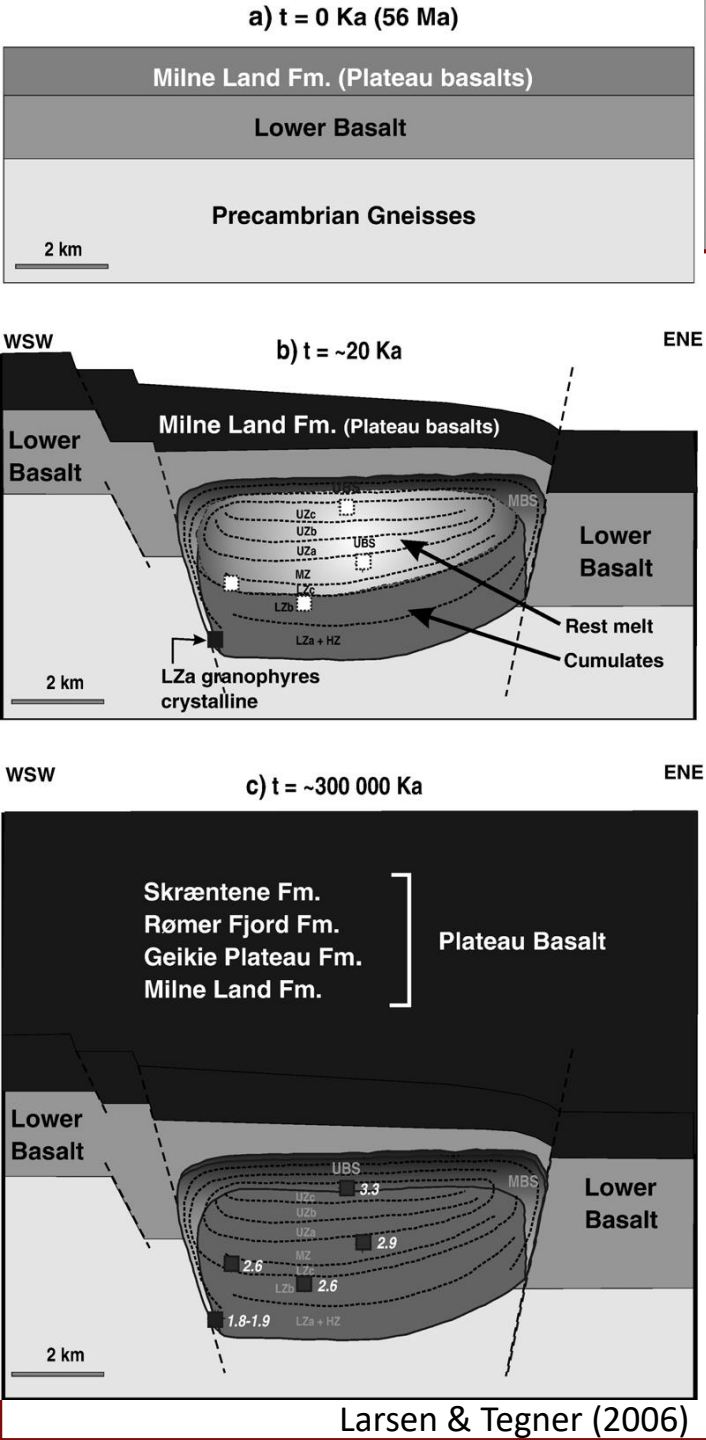


Svensen et al. (2004)



Extensive degassing from contact metamorphism around the Paleocene-Eocene boundary

NAIP Activity - lavas



Larsen & Tegner (2006)

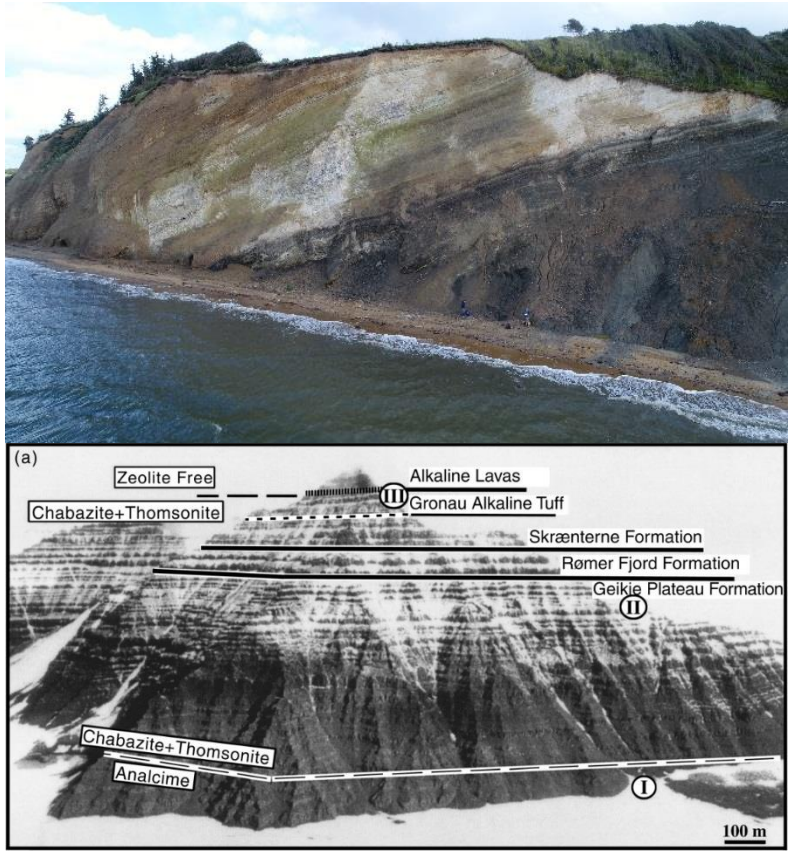
Skaergaard began crystallization at 56.02 Ma (Wotzlaw et al., 2012)

Skaergaard buried by **5.3-6.3 ±2.7 km** of basalts as it crystallized (Larsen & Tegner, 2006)

Ash -17 in Denmark dated to 55.6 ± 0.12 Ma (Storey et al., 2007)

Ash -17 matches the Gronau Tuff at the top of the East Greenland lavas (Heister et al., 2001)

Significant eruptive activity from 56.0 to 55.6 Ma



Fur Island, Denmark: An ideal PETM locality

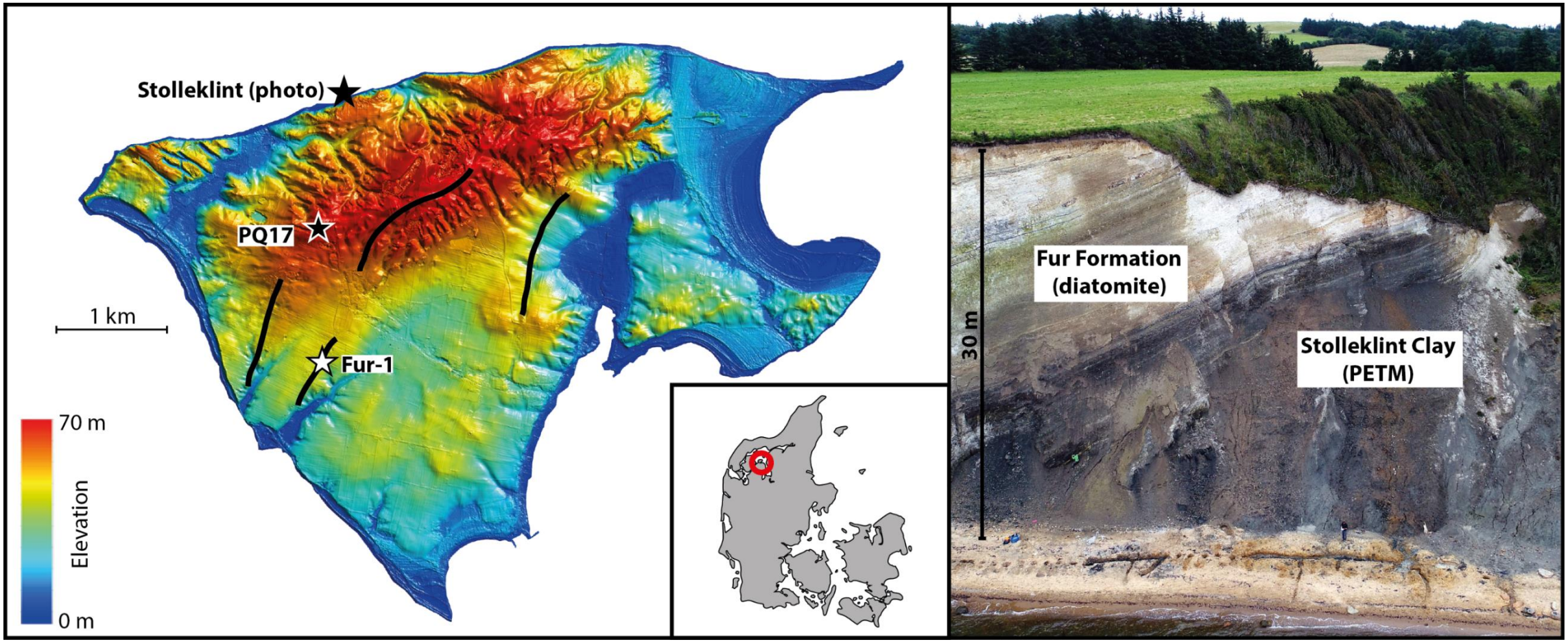
Close enough to the NAIP to record volcanic and climatic proxies in the same section

Expanded sections allow for decadal (possibly even annual) resolution

Thermally immature sediments: numerous inorganic and organic proxies can be used

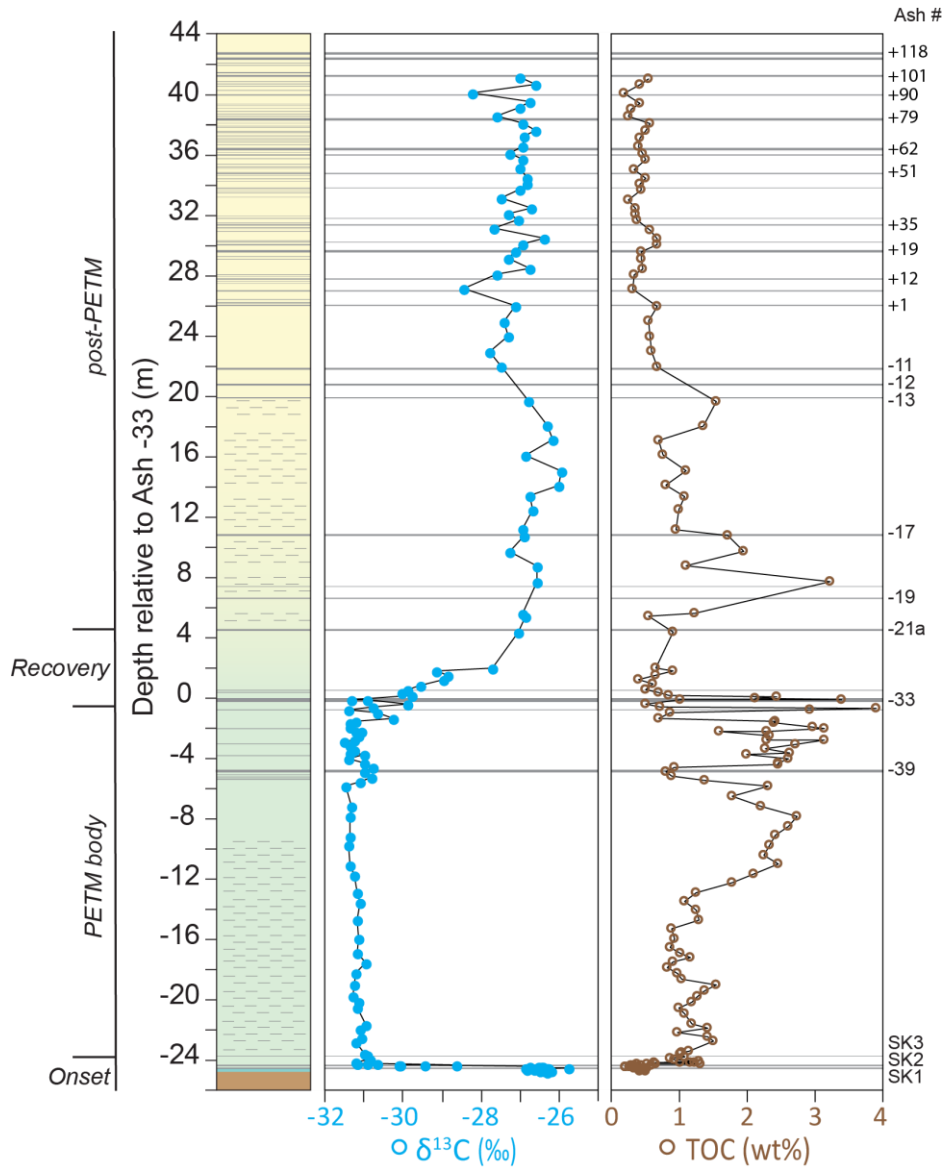
Hundreds of tephra layers present, which allows high precision tephrochronology

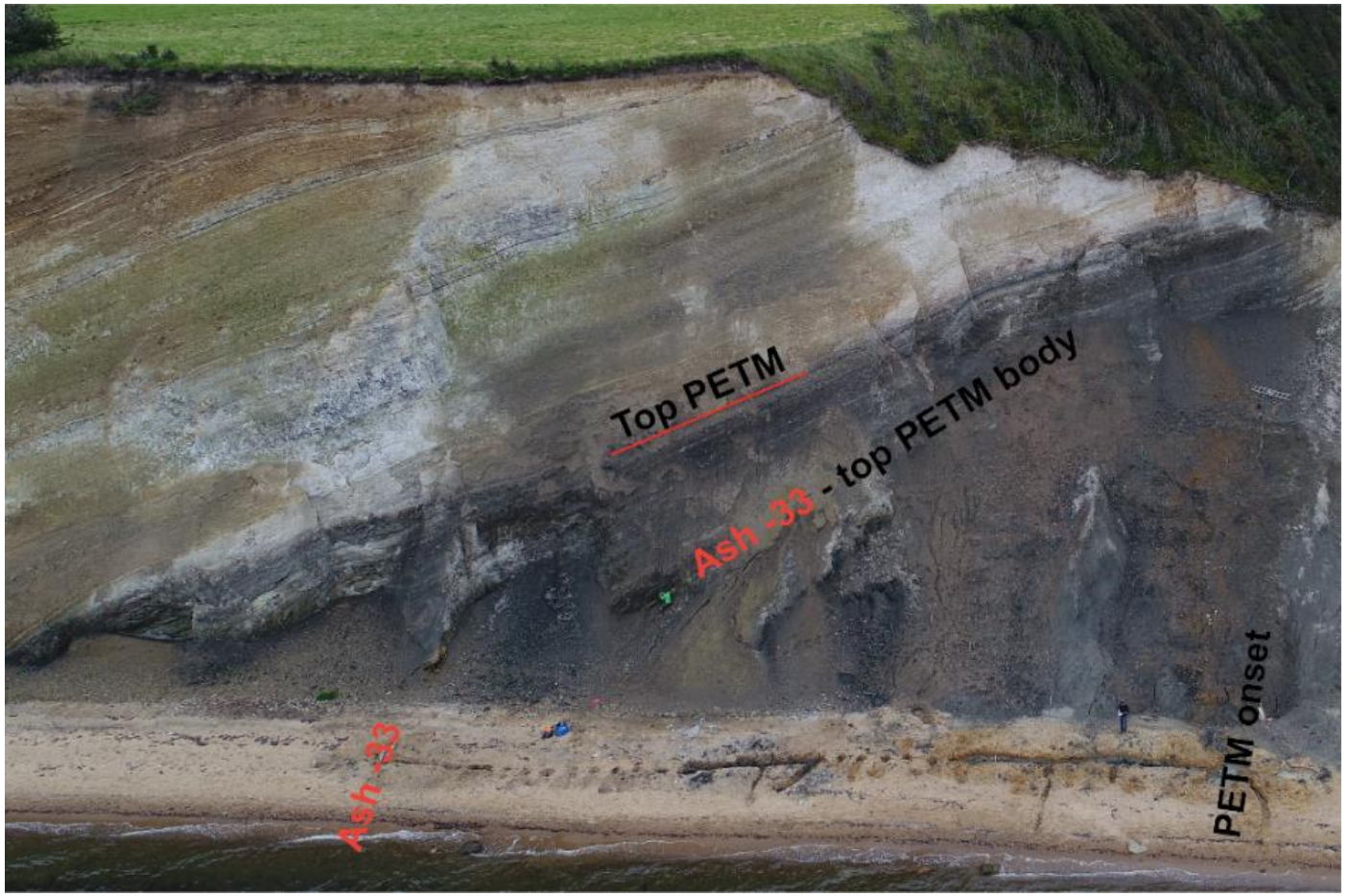
Fur Island: An ideal PETM locality



The Stolleklint Clay (PETM) & Fur Formation (Eocene) are well preserved on Fur Island
PETM section is 24 m thick and has experienced nearly no diagenesis

Stolleklint Beach Section



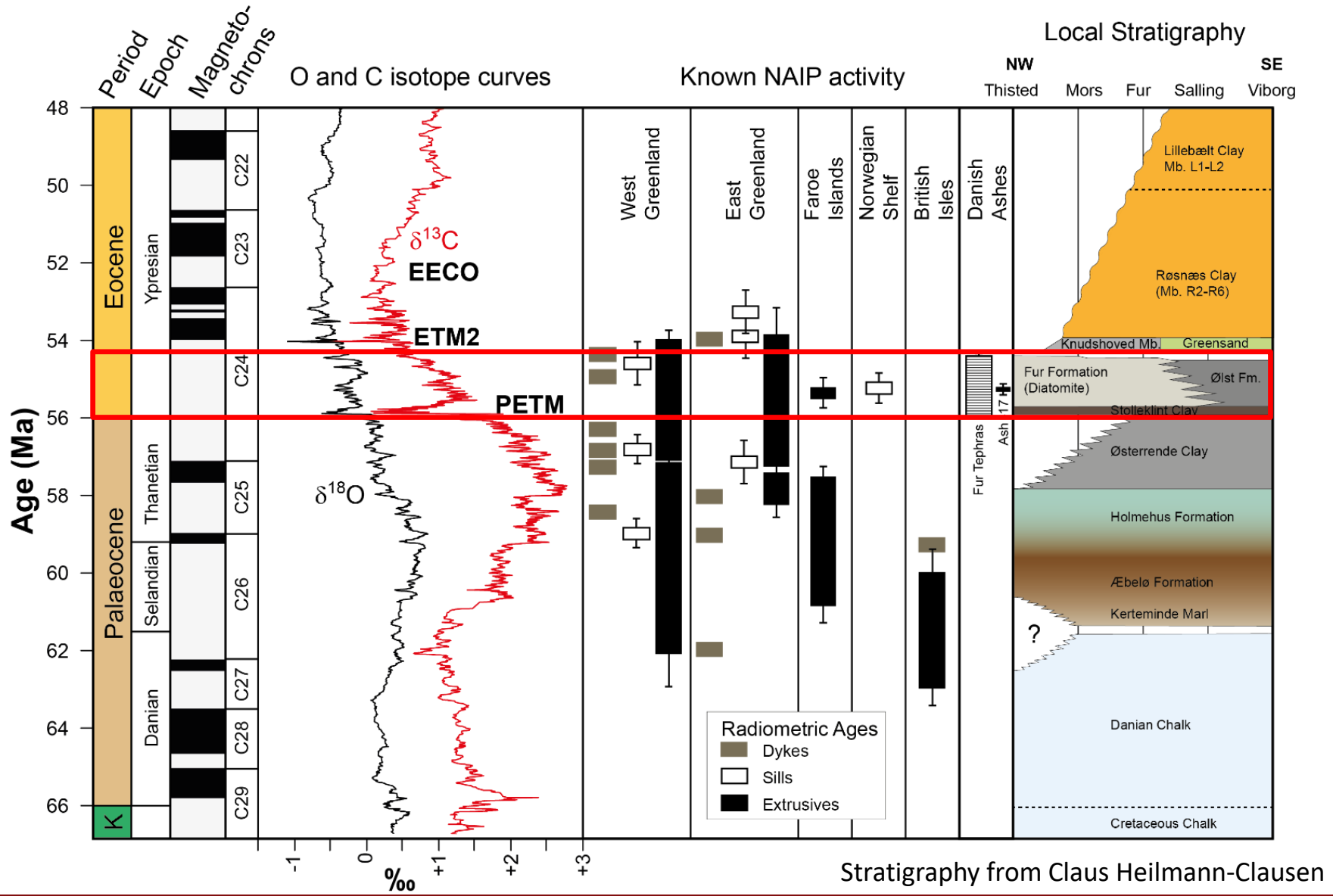


Legend lithology

- Fur Fm, diatomite
- Stolleklint Clay
- Glauconitic clay
- Holmehus Fm, clay
- Volcanic ash
- Lamination

Stokke et al. (in review)

Volcanic Proxies



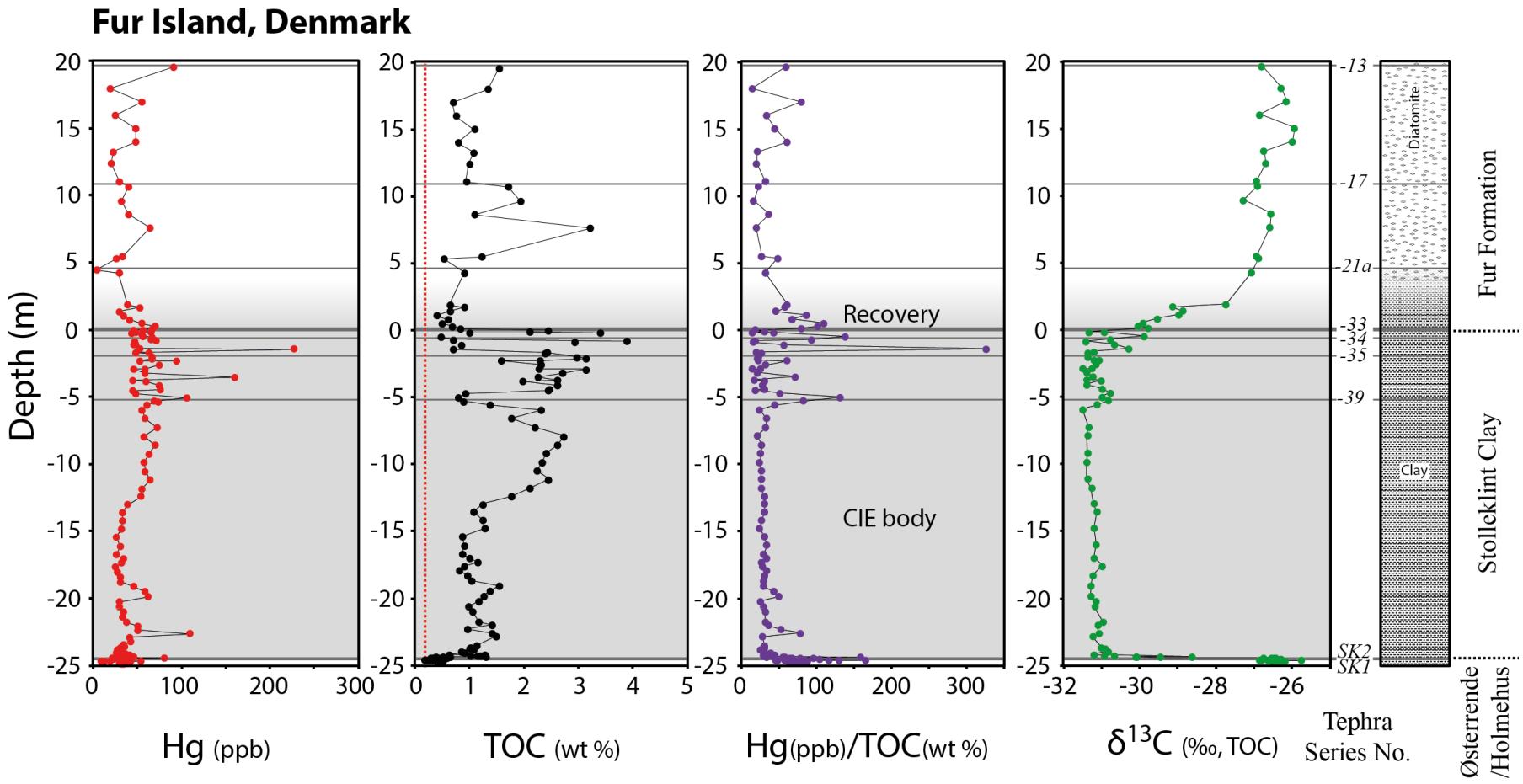
Stratigraphy from Claus Heilmann-Clausen

Danish sequence contains over 180 ash layers

Exceptional tephra preservation

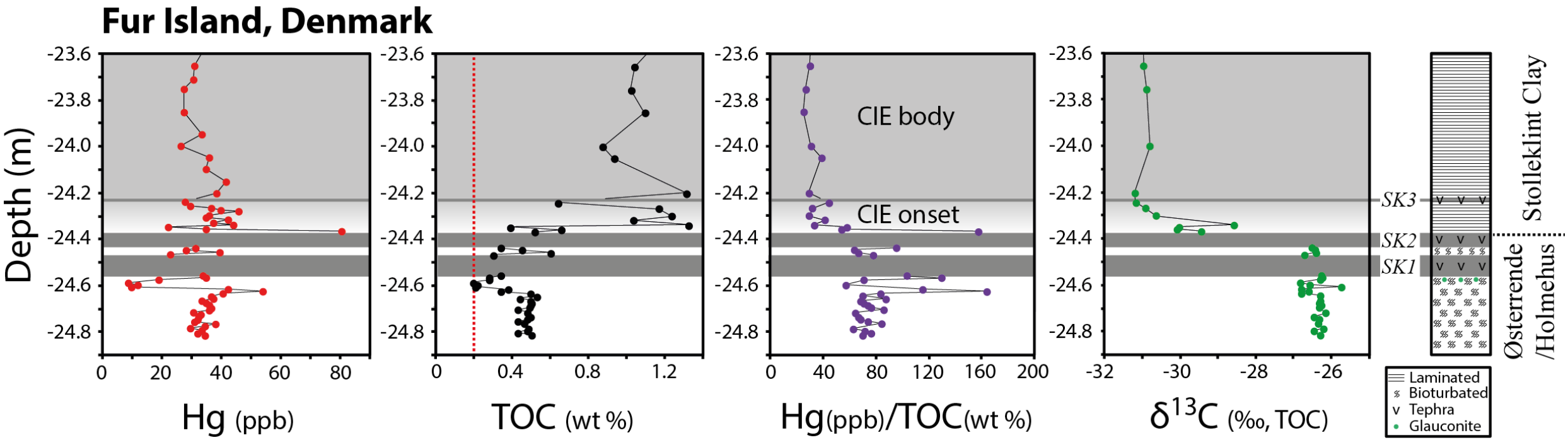
Other key volcanic proxies present (Hg, Ir, $^{187}Os/^{188}Os$)

Hg Anomalies: Fur, Denmark



Mercury anomalies coincide with tephra-rich intervals before and after the PETM, but importantly they are absent from the PETM body on Fur Island (Jones et al., 2019)

Hg Anomalies: Fur, Denmark



Hg anomalies at the PETM onset. There is at least a 10 x increase in sedimentation rates into the body of the PETM, so the timing of the onset of volcanic activity prior to the PETM onset is currently poorly constrained. (Jones et al., 2019)

Recent & Upcoming work

Pogge von Strandmann et al. (**in review**). Lithium isotope evidence for enhanced weathering and erosion during the Palaeocene-Eocene Thermal Maximum. *Proceedings of the National Academy of Sciences (PNAS)*.

Stokke et al. (**in review**). Temperature changes across the Paleocene-Eocene Thermal Maximum – a new high-resolution TEX_{86} temperature record from the Eastern North Sea Basin. *Earth and Planetary Science Letters*.

Longmann et al. (**in review**). Widespread diagenesis of volcanic deposits accelerated termination of the Paleocene-Eocene Thermal Maximum. *Nature Geoscience.*

Heimdal et al. (**2020**). Thermogenic carbon release from the Central Atlantic Magmatic Province caused major end-Triassic carbon cycle perturbations. *Proceedings of the National Academy of Sciences (PNAS)*, in press.

Berndt et al. (**2019**). Breakup volcanism and consequences for climate change – MagellanPlus Workshop report. *Scientific Drilling*, 26, 69-85.

Jones et al. (**2019**). Mercury anomalies across the Palaeocene–Eocene Thermal Maximum. *Climate of the Past*, 15 (1), 217-236.

Future Work

Hydromagmatic origins of basaltic tephra layers in Denmark (Stokke et al., in prep.)

Volcanic proxies and Os isotopes in pre-PETM sediments (Jones et al., in prep.)

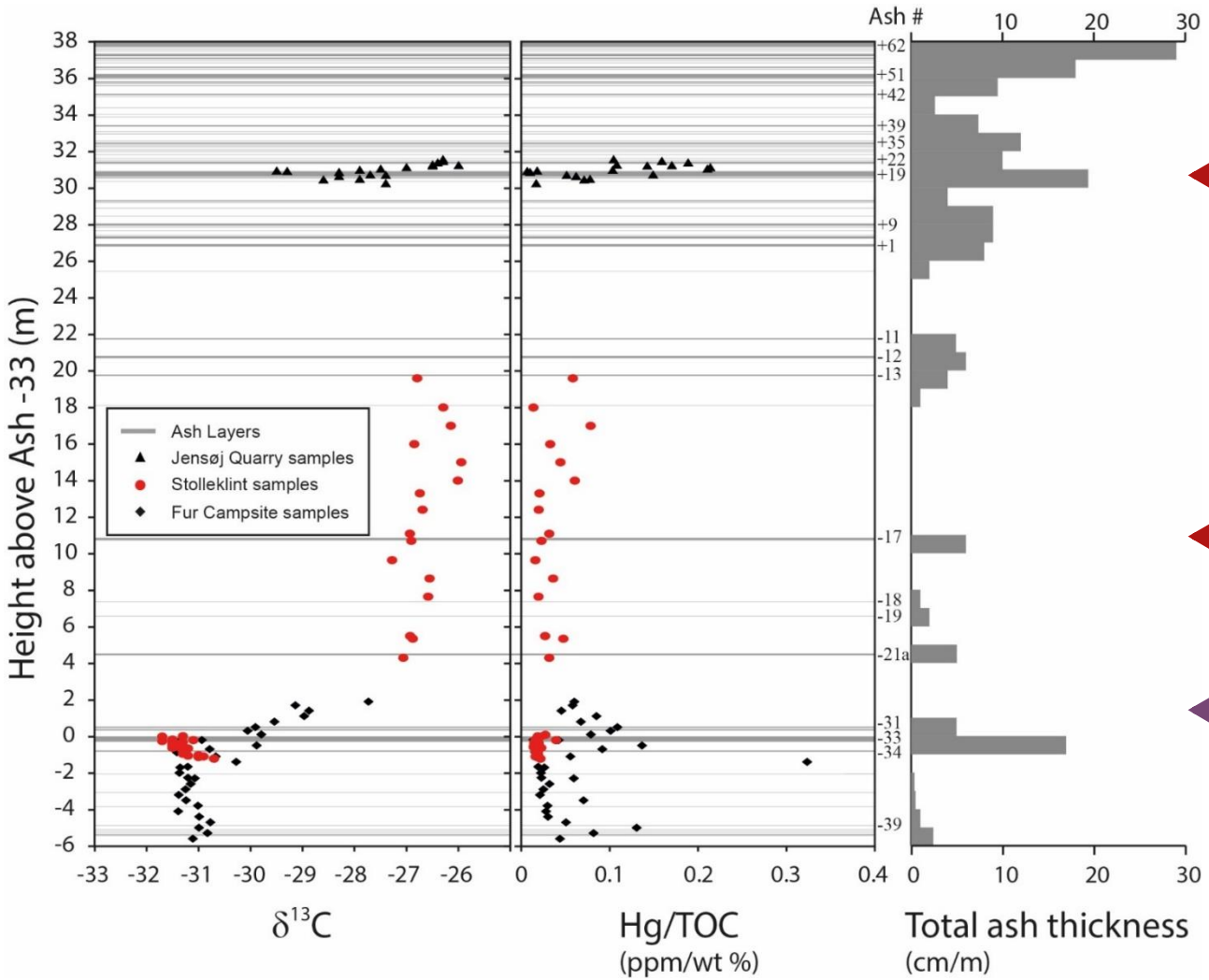
Improved geochronology of the PETM using U-Pb dating of tephra layers (Jones et al., in prep.)

Constraining weathering intensity in the Stolleklint Clay during the PETM (Stokke et al., in prep.)

Sadly we cannot present the preliminary data here, but we would be happy to chat with you about this work either in the EGU session or elsewhere

There are several areas of possible collaboration going forward:

Improved Geochronology



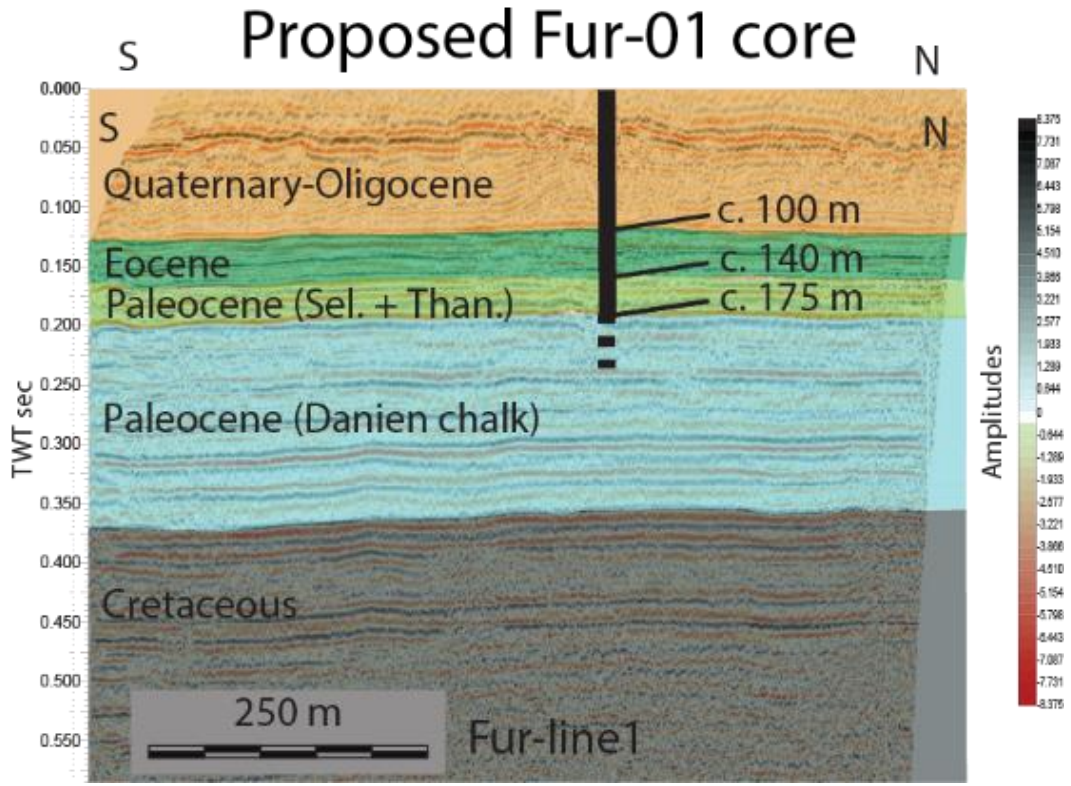
Ash +19 = ~55.5 Ma
(U-Pb; Jones et al., in prep.)

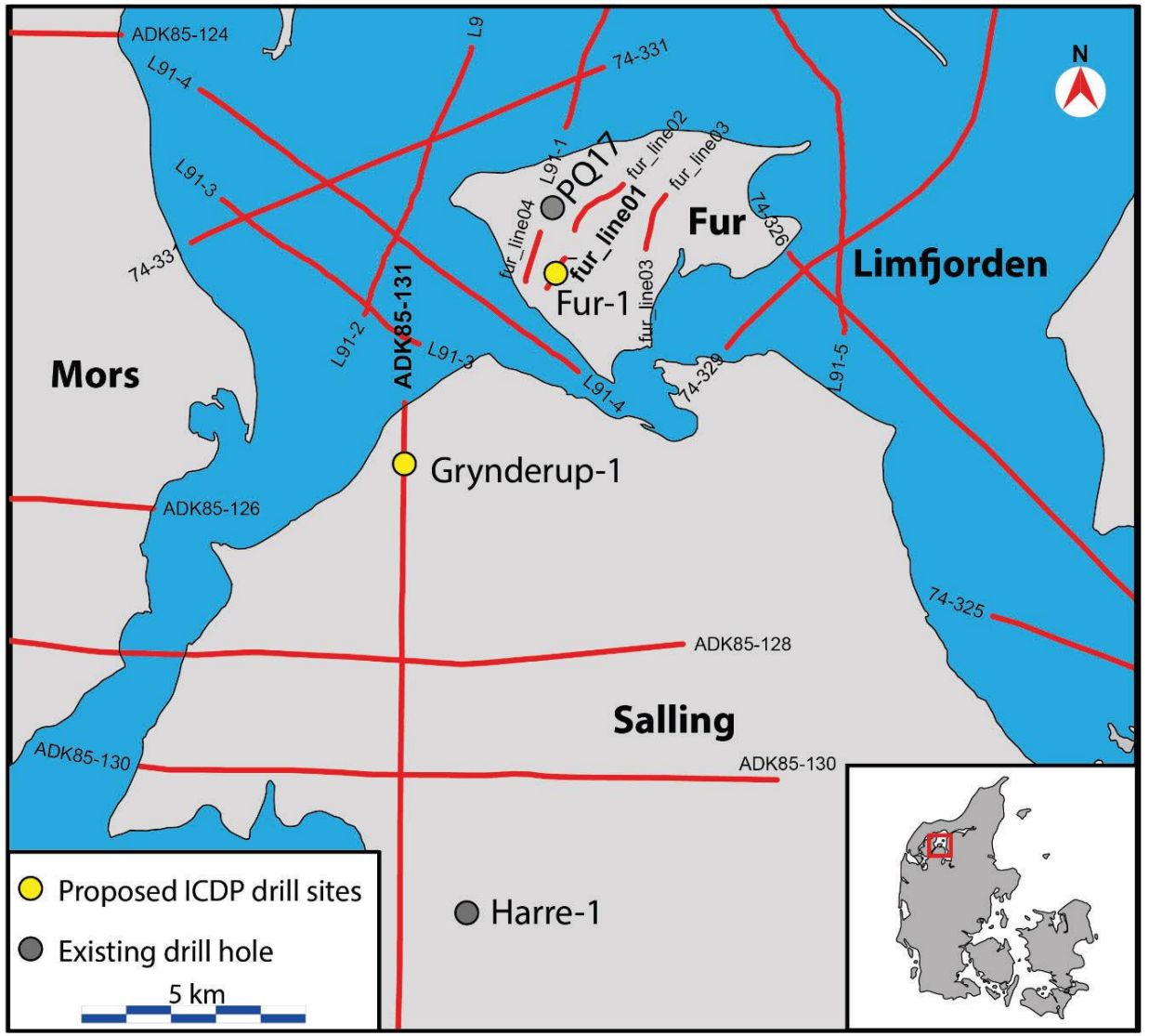
Ash -17 = 55.6 ± 0.12 Ma
(Ar/Ar; Storey et al., 2007; corrected)

Ash -31(?)* = 55.765 ± 0.086 Ma
(U-Pb, Charles et al., 2011)
***Svalbard**

U-Pb dating is ongoing. We have material for Ar/Ar dating if a lab wants to collaborate

ICDP Application





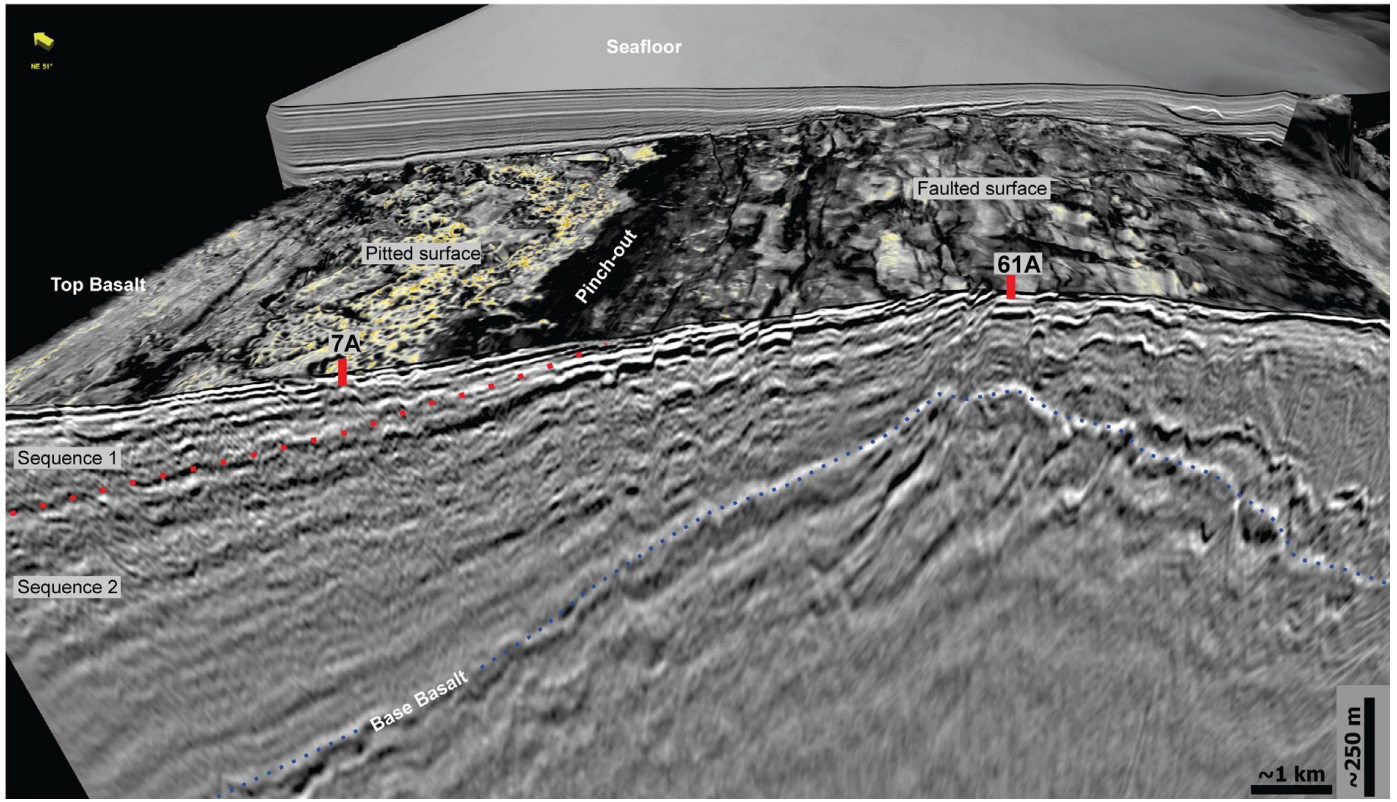
Current ICDP application (PVOLC) to drill entire Paleogene sequence (including pre-PETM)

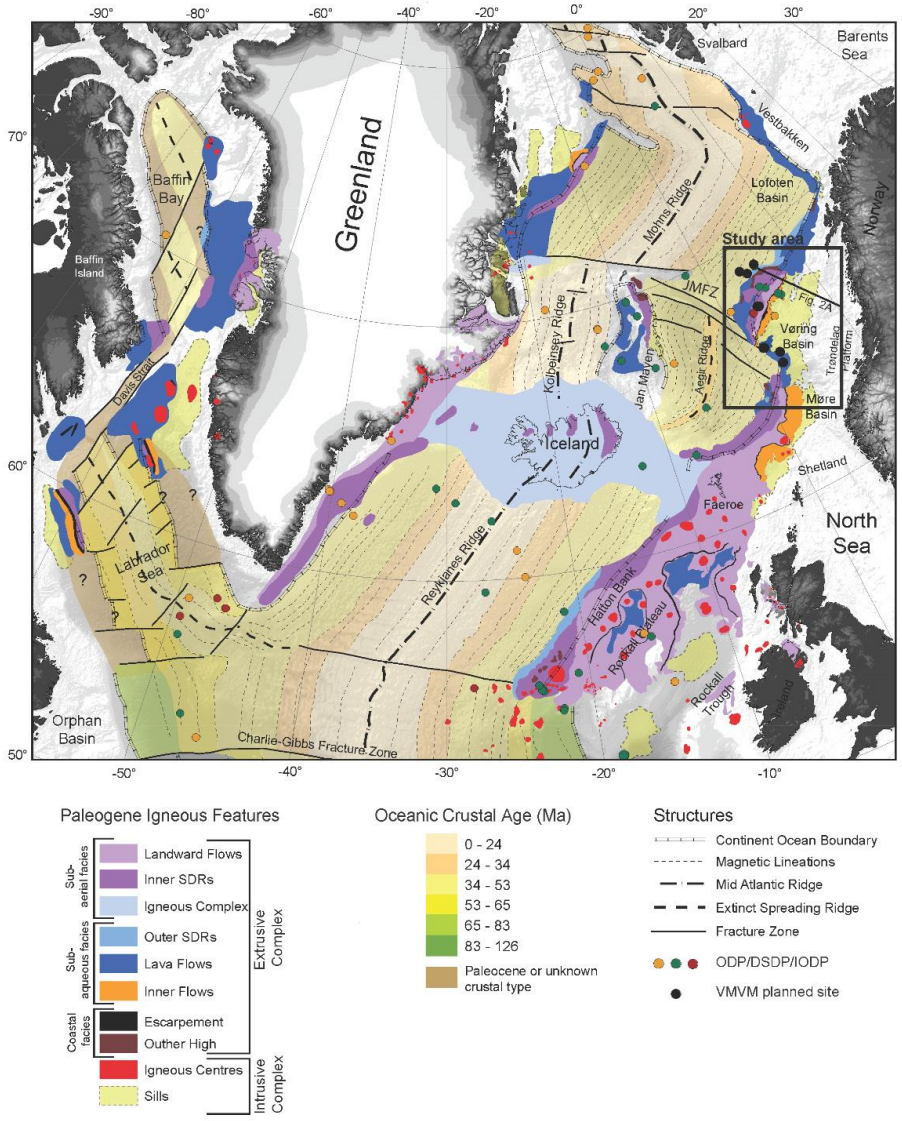
If successful, collaborations welcome!

IODP Application

Current IODP application (P944-Full2) to drill Vøring Basin and Norwegian margin (see Berndt et al., 2019)

If successful, collaborations welcome!





Project ASHLANTIC

The Research Council of Norway

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Artist in Residence: oliviajonesartist.com