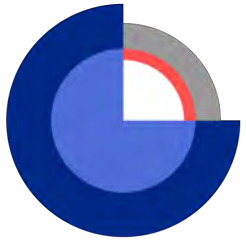
Thermotectonic development of the Wandel Sea Basin, North Greenland

Peter Japsen[1], Paul F. Green[2] & James A. Chalmers[1]

[1]Geological Survey of Denmark and Greenland (GEUS)
[2]Geotrack International

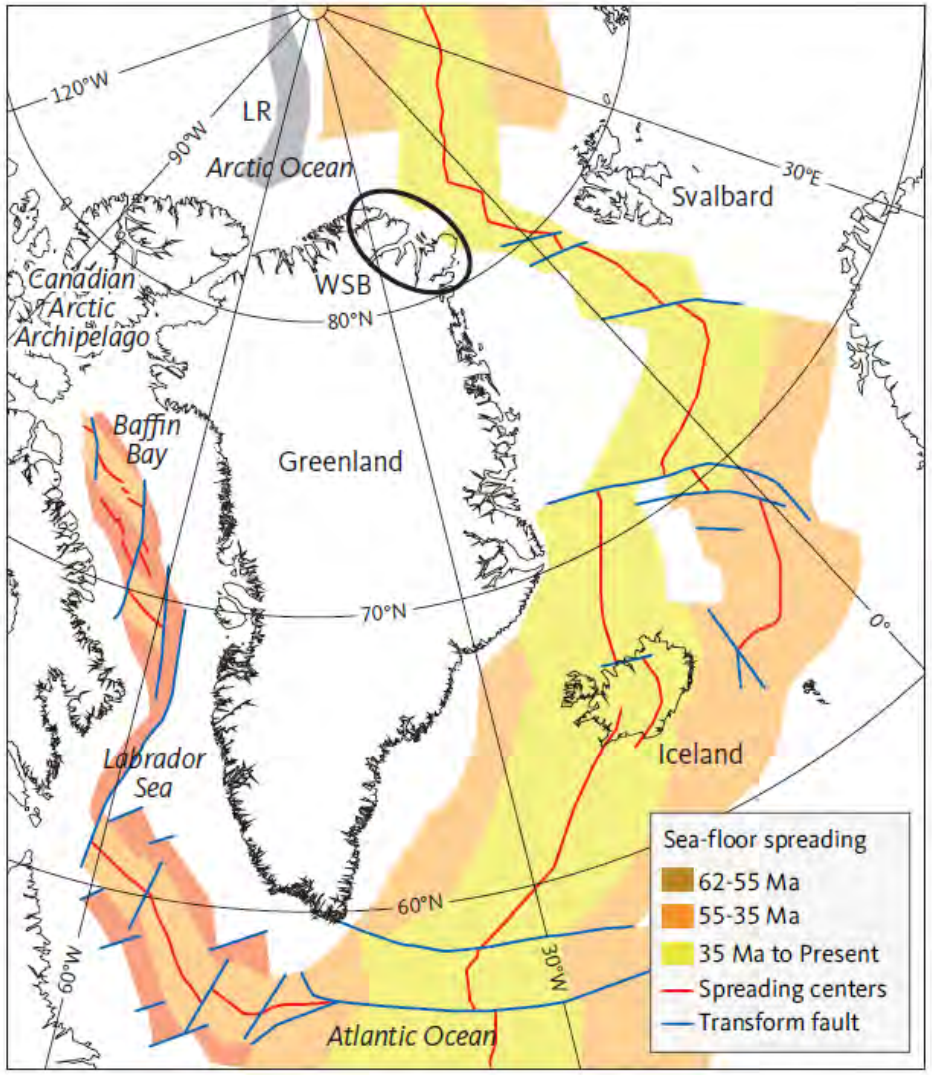






GEUS

The Carboniferous – Palaeogene Wandel Sea Basin (WSB) and the Eurekan Orogeny

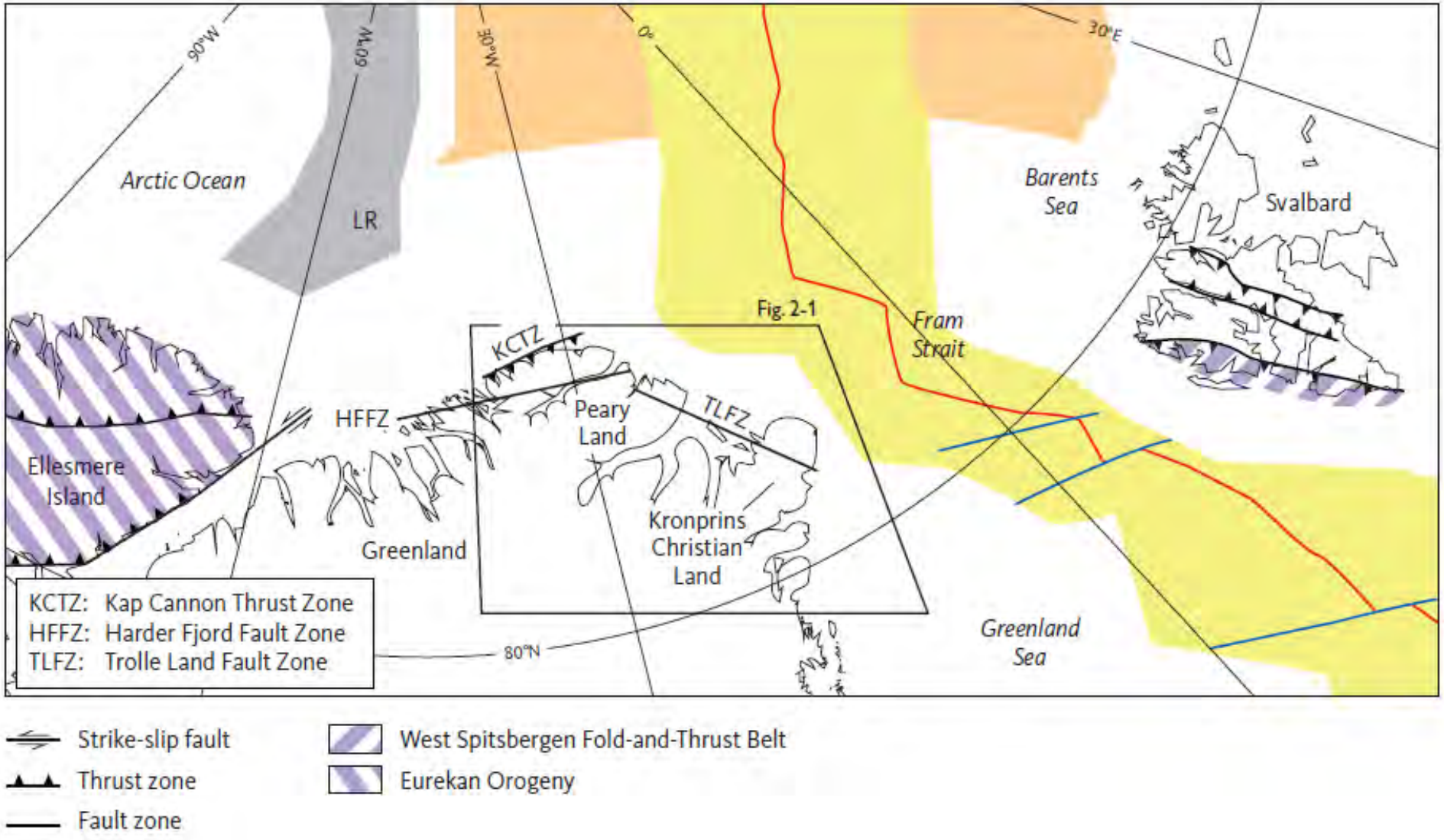


Eurekan Orogeny: Deformation caused by the Palaeogene convergence between Greenland and the High Arctic

- Arctic Canada (Okulitch & Trettin 1991; Embry & Beauchamp 2008)
- Wandel Sea Basin: Kronprins Christian Land Orogeny (Håkansson & Pedersen 2001)
- Svalbard: the West Spitzbergen Orogeny (Steer et *al.* 1985; Dallmann et *al.* 1993)

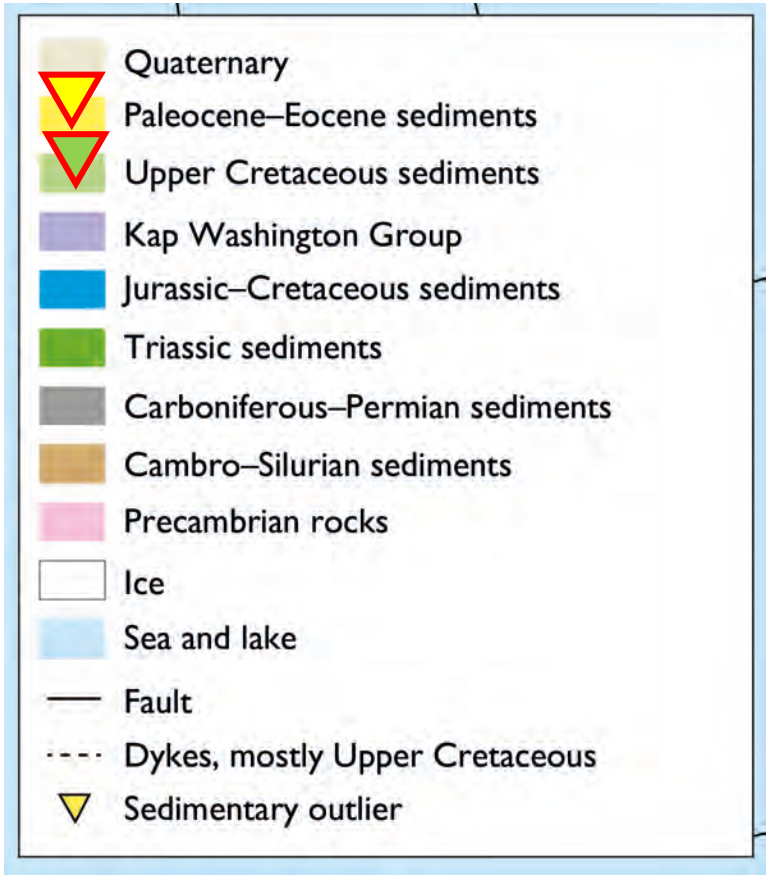
Brozena et *al.* (2003), Oakey & Chalmers (2012), Gaina et *al.* (2017)

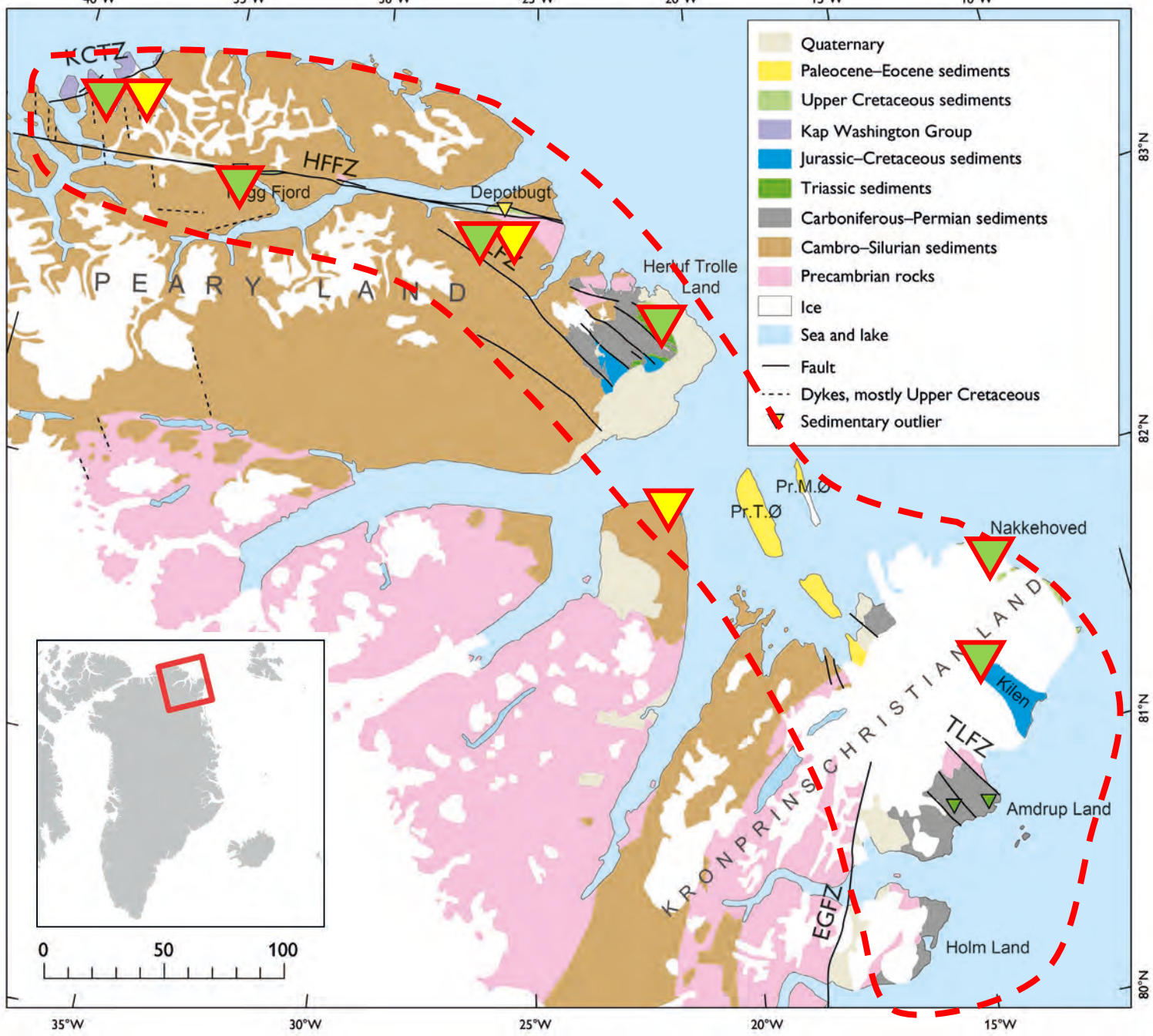
The Carboniferous – Palaeogene Wandel Sea Basin (WSB) and the Eurekan Orogeny



Piepjohn & von Gosen 2001; Oakey & Chalmers 2012; Piepjohn et al. 2015

Carboniferous – Palaeogene Wandel Sea Basin

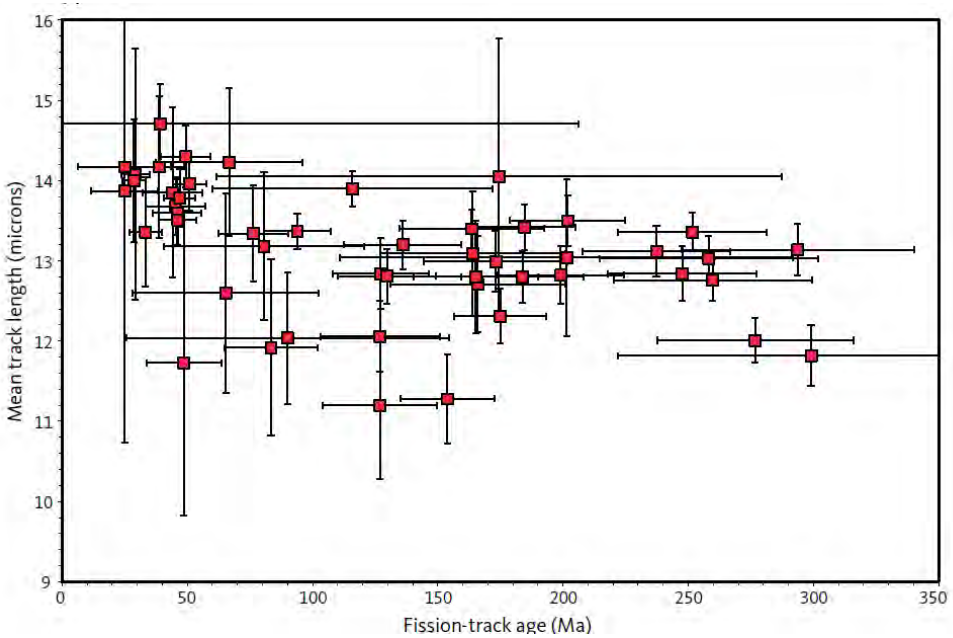


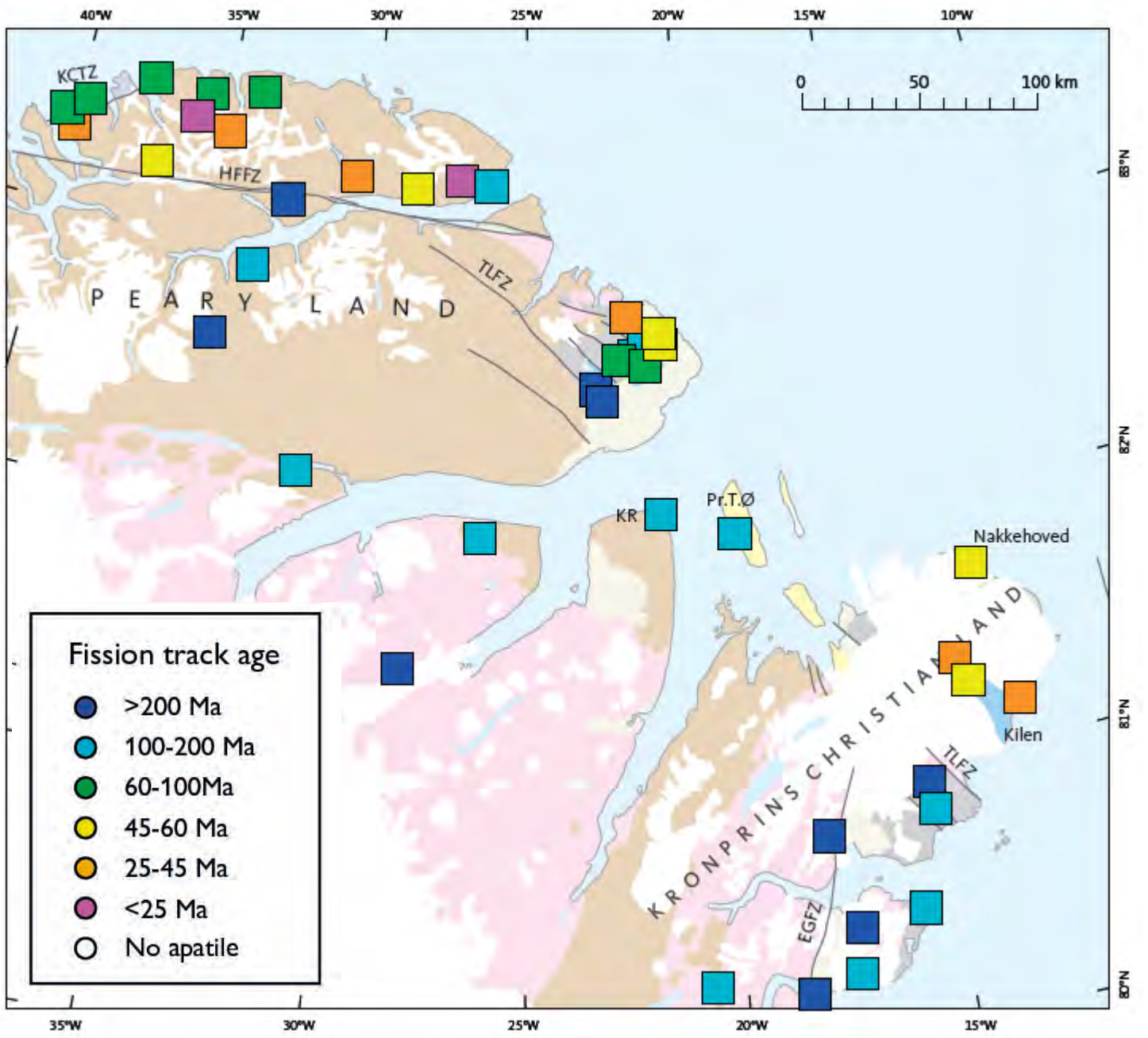


Oakey & Chalmers 2012; Gion et al. 2017

Escher & Pulvertaft 1995; Hovikoski et al. 2018

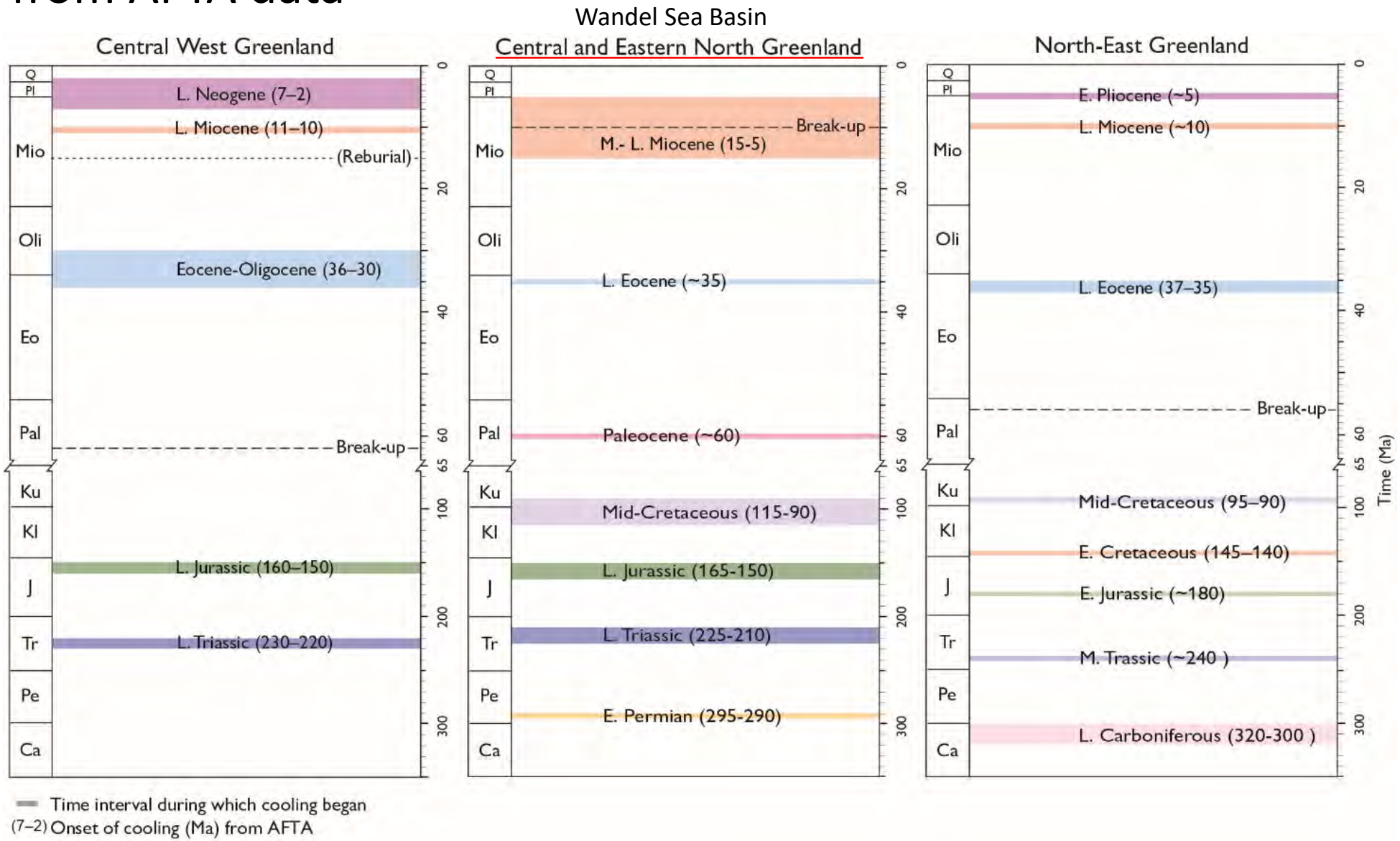
Apatite fission-track analysis (AFTA) data in 46 samples





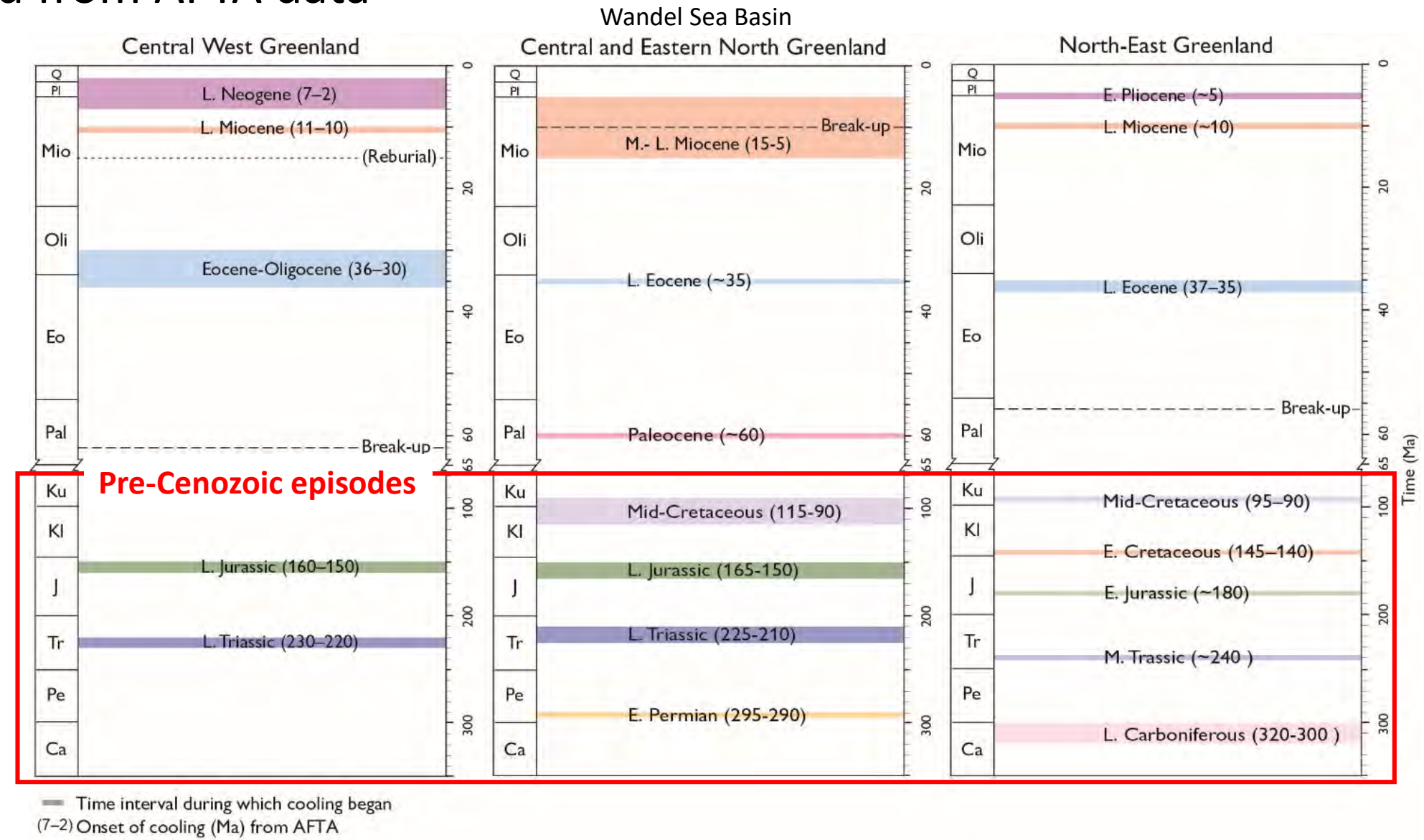
Timing of regional episodes of cooling and exhumation

estimated from AFTA data



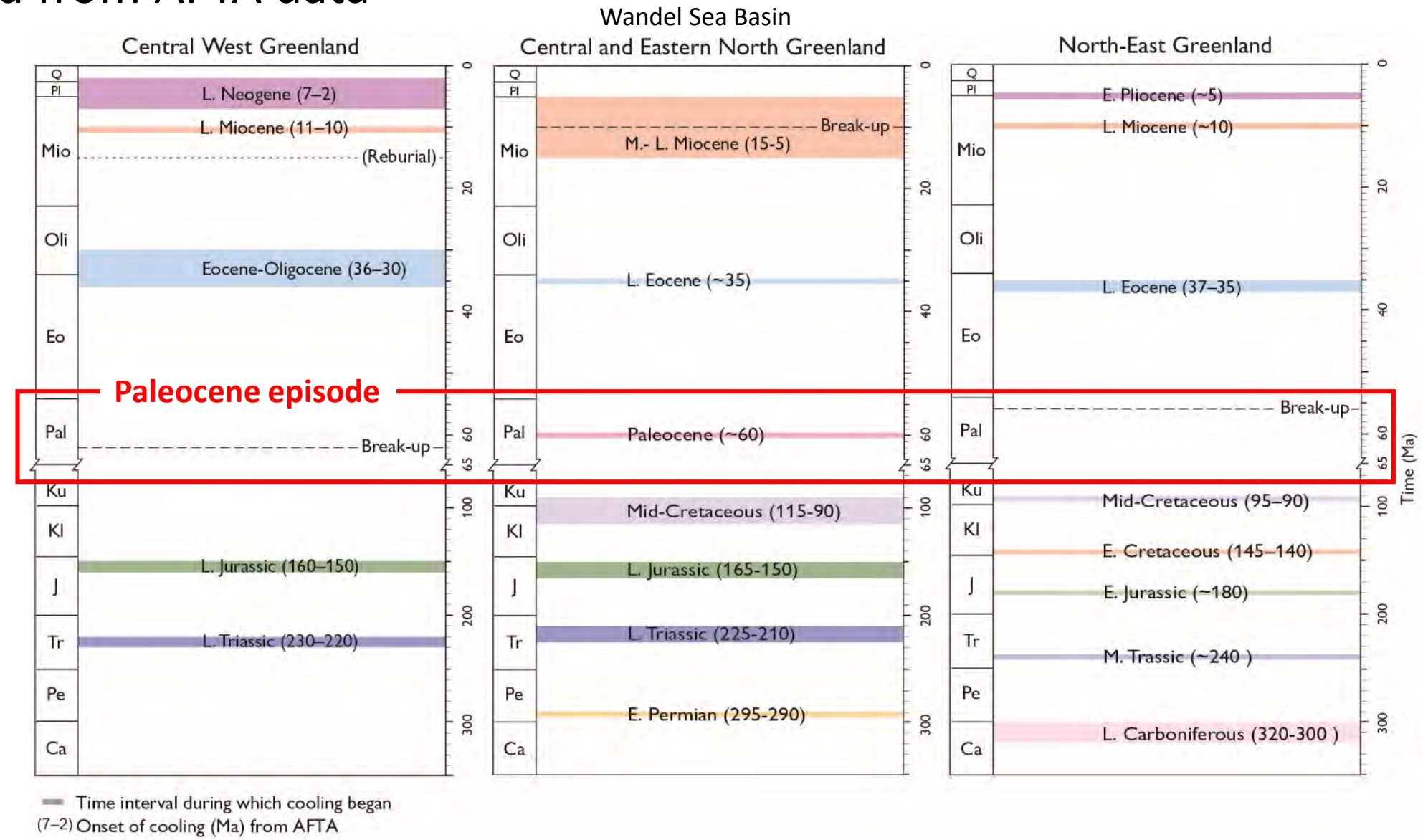
Timing of regional episodes of cooling and exhumation

estimated from AFTA data



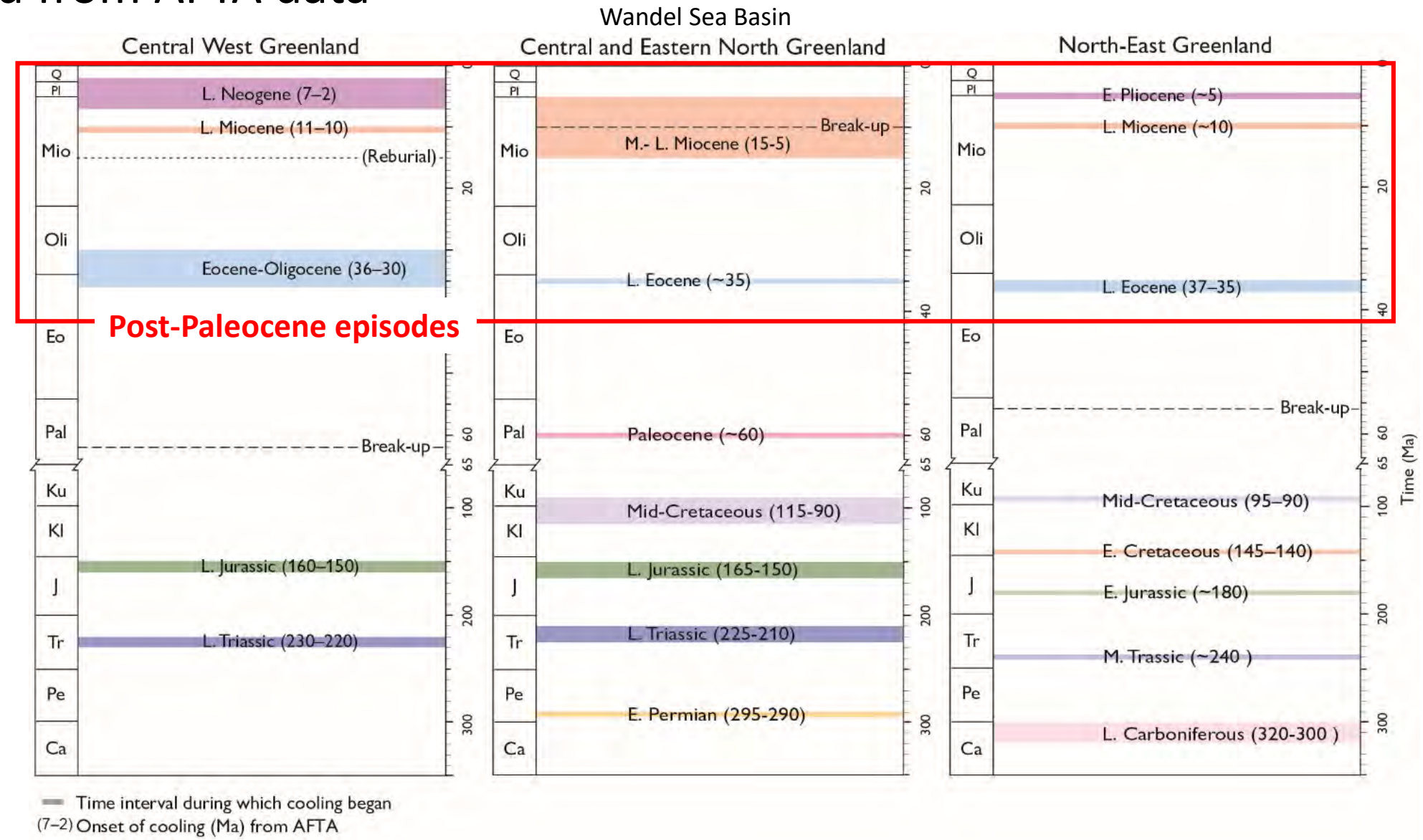
Timing of regional episodes of cooling and exhumation

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Timing of regional episodes of cooling and exhumation

estimated from AFTA data



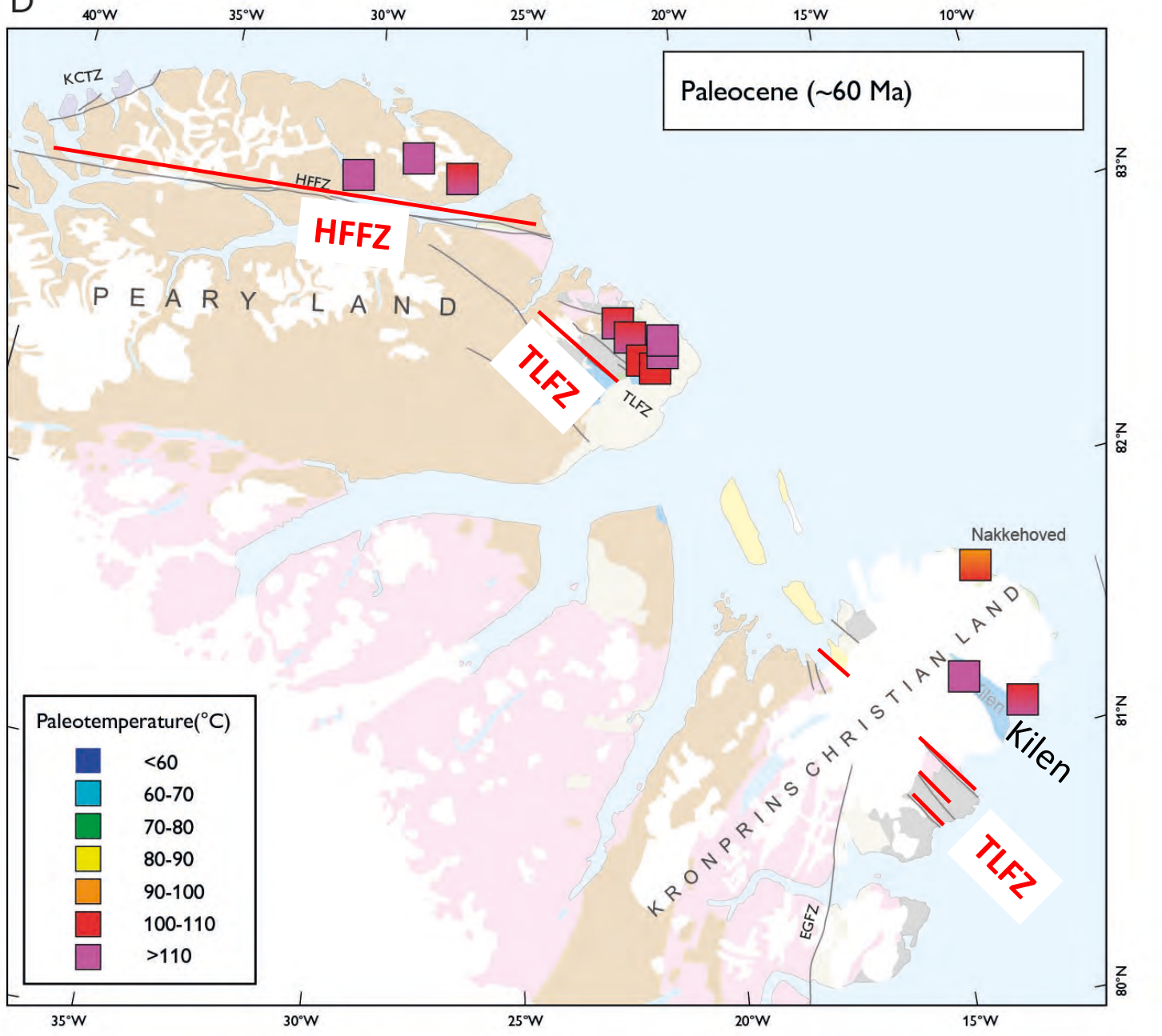
Palaeotemperatures prior to cooling at ~60 Ma

Exhumation affected the major fault zones of the Wandel Sea Basin

>3 km Cretaceous to Paleocene sediments were removed within the fault zones

HFFZ: Harder Fjord Fault Zone
TLFZ: Trolle Land Fault Zone

30°C/km, 20°C at the surface

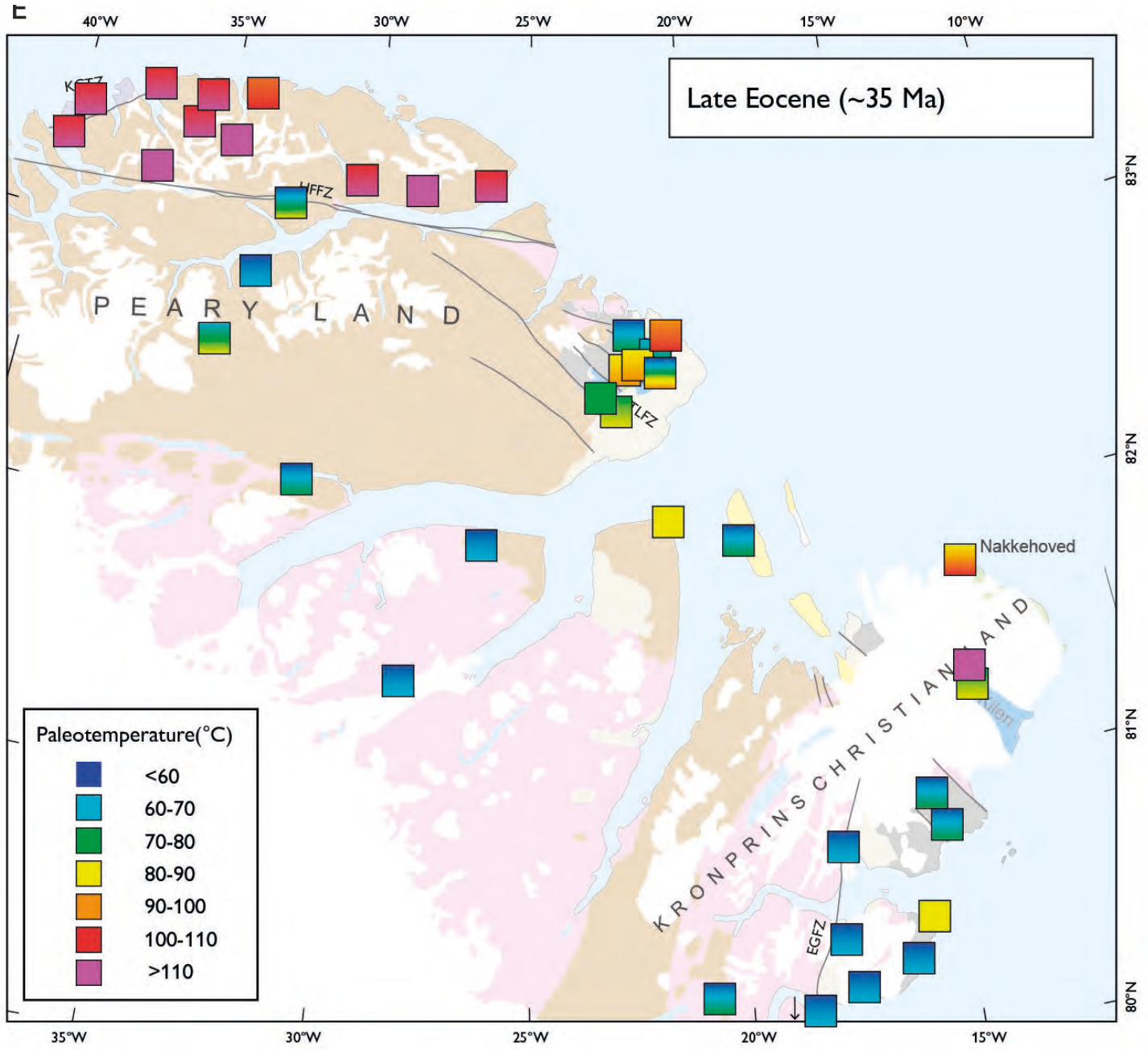


Palaeotemperatures prior to cooling at 35 Ma

Palaeotemperatures around 80-90°C (outside northern Peary Land)

Also for the Palaeogene Thyra Ø Fm: Corresponds to a cover of 2.5 km of Palaeogene sediments

30°C/km, 10°C at the surface

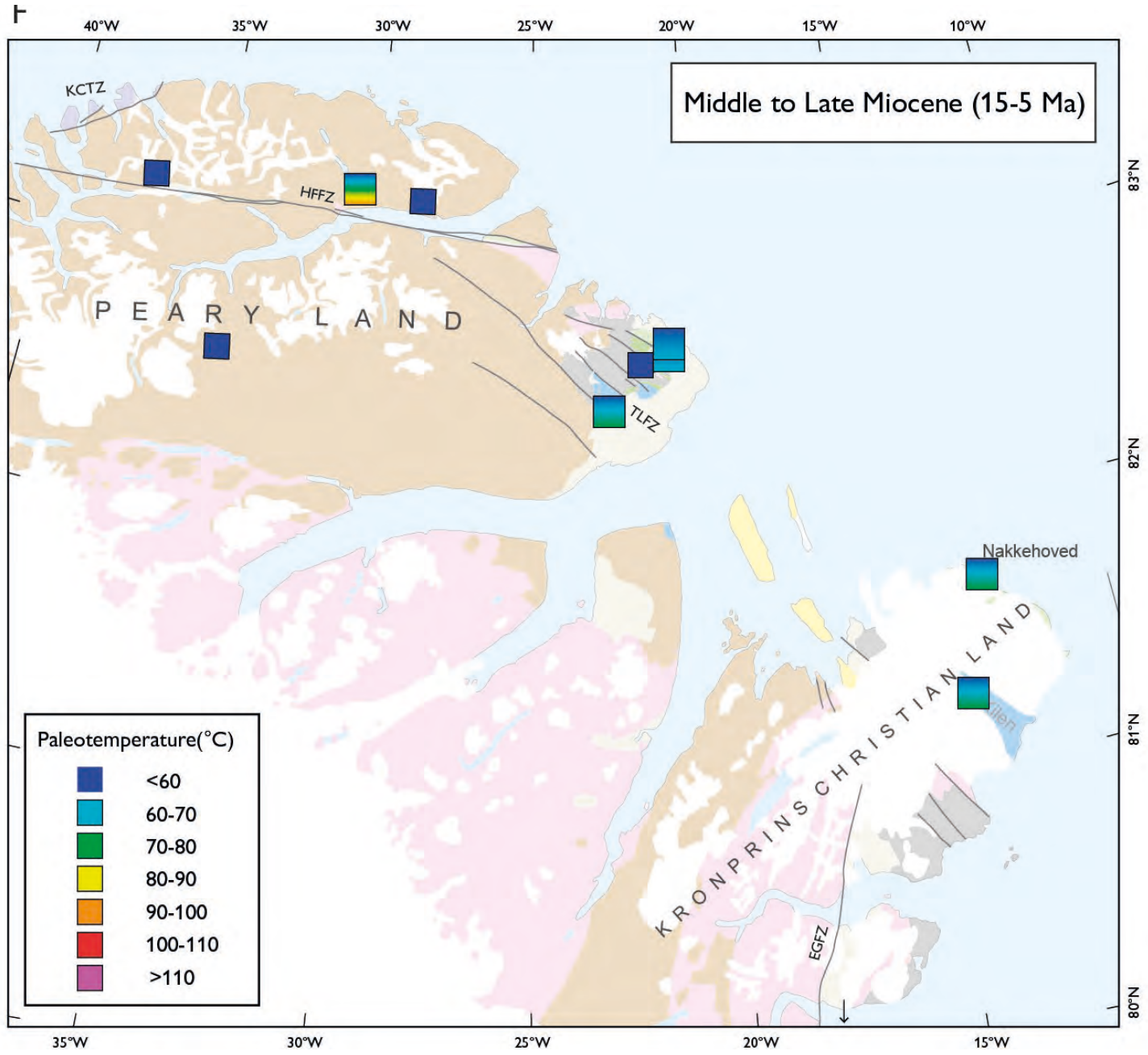


Palaeotemperatures prior to cooling beginning between 15 and 5 Ma

Synchronous with late Miocene (~10 Ma) uplift and incision in NE Greenland

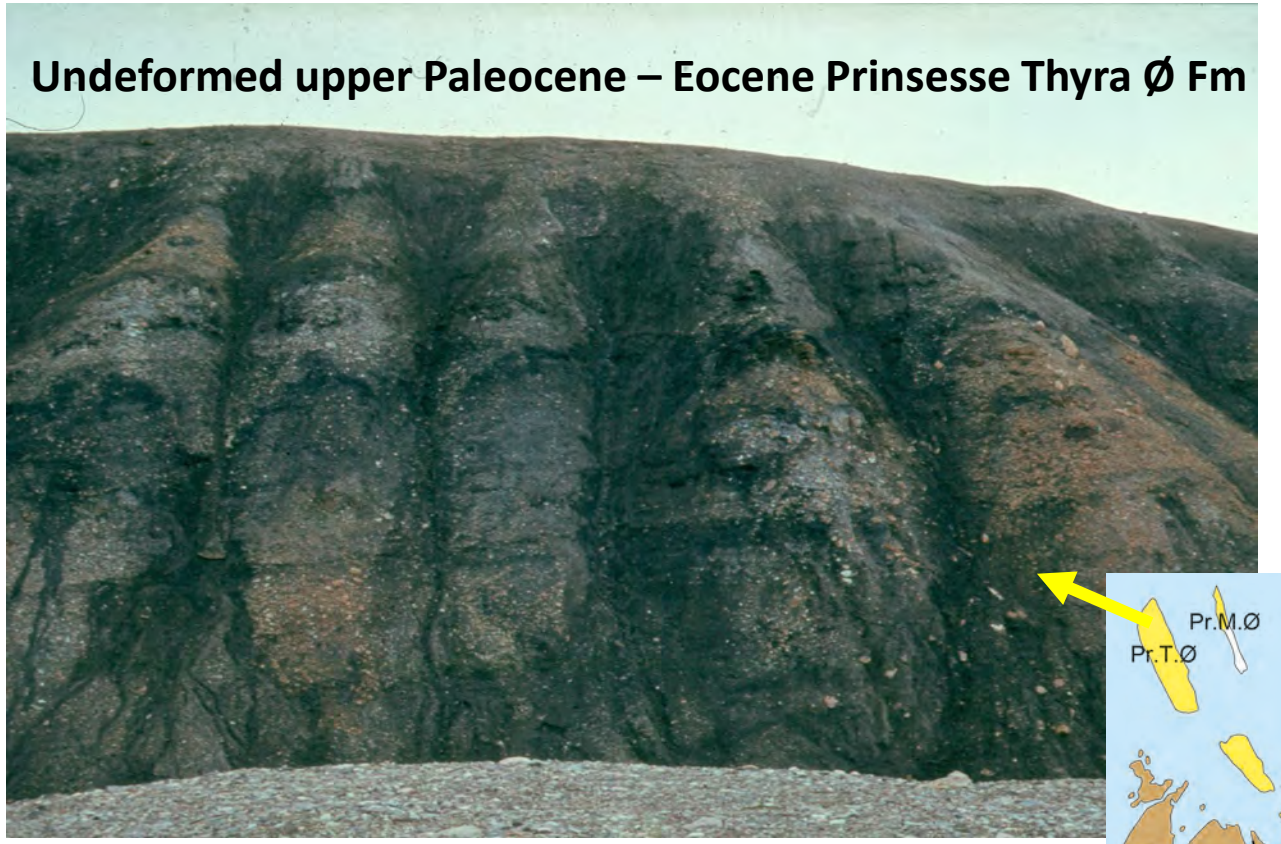
Maximum palaeotemperatures at sea level correspond to burial below a 1.5 km rock column

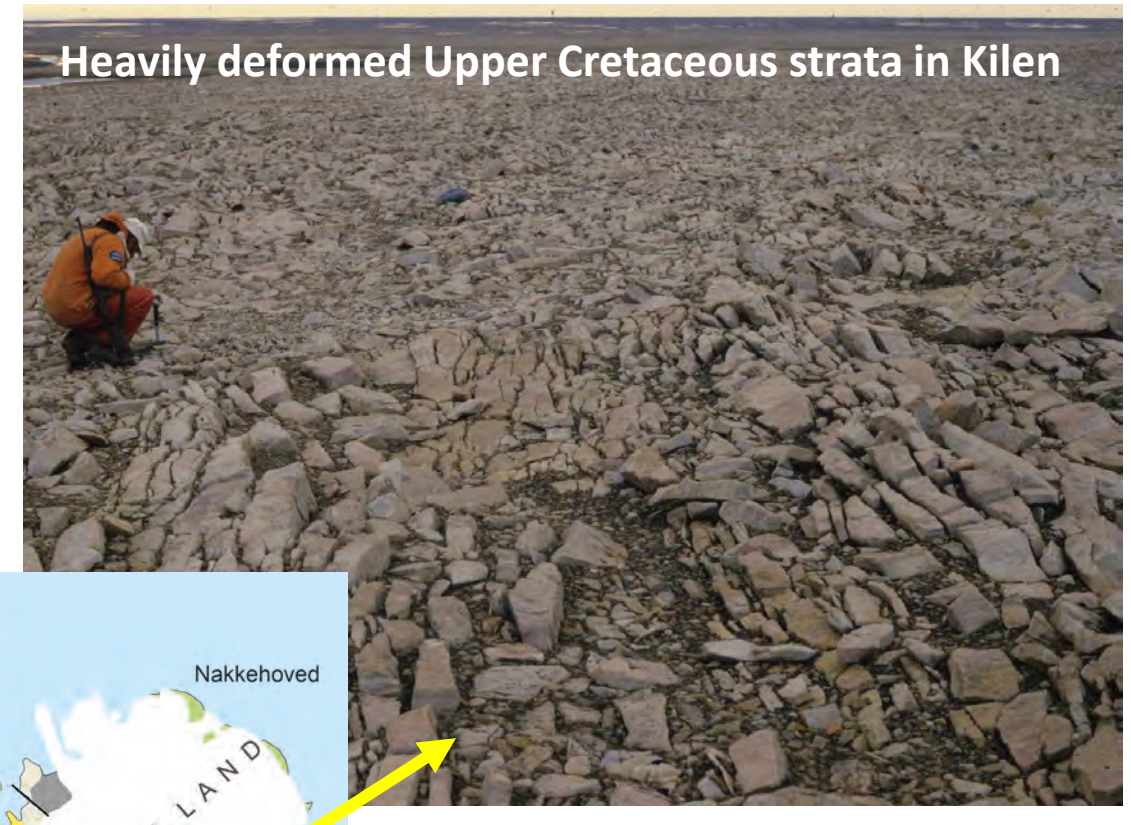
30°C/km, 5°C at the surface

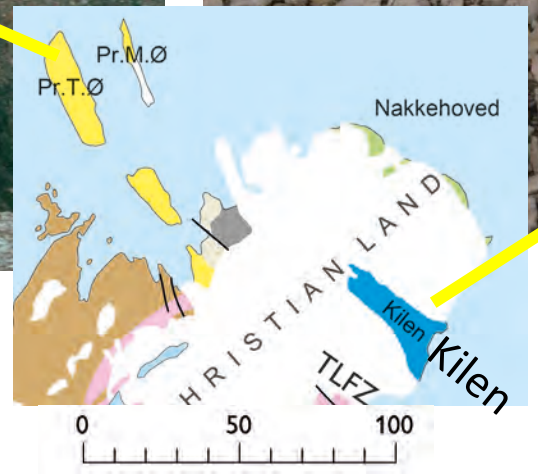


Exhumation of fault zones at 60 Ma vs the Eurekan Orogeny

Kronprins Christian Land Orogeny: Deformation of pre-Cenozoic strata







Håkansson & Pedersen 2001; 2015

Timing of the compressional event in the Wandel Sea Basin?

1. During a brief period around the K-T boundary (Håkansson & Pedersen 2015)

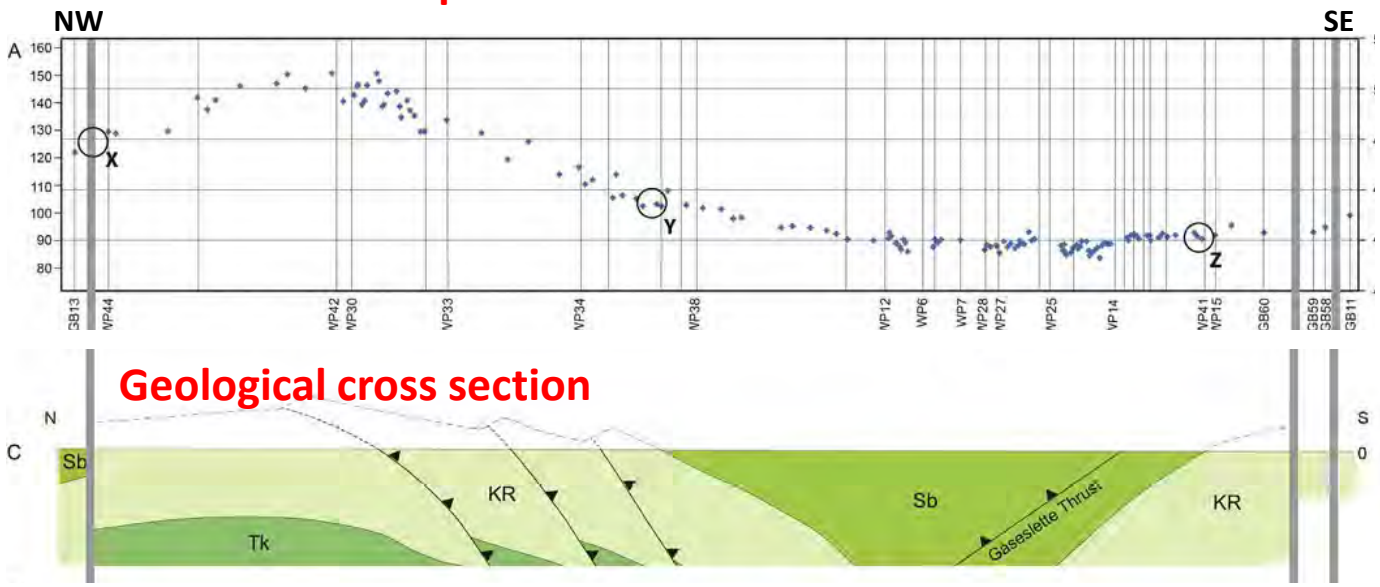
2. During the Eocene (von Gosen & Piepjohn 2003)

3. During the late Paleocene – early Eocene (Døssing et al. 2010; Svennevig et al. 2016).

Late Cretaceous rifts underwent N-S compression

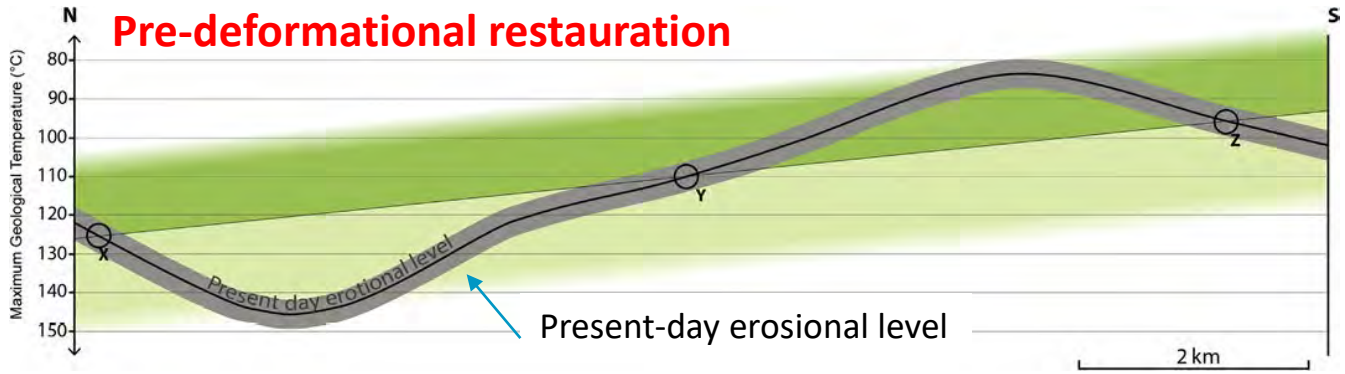
Case study from Kilen (Trolle Land Fault Zone)

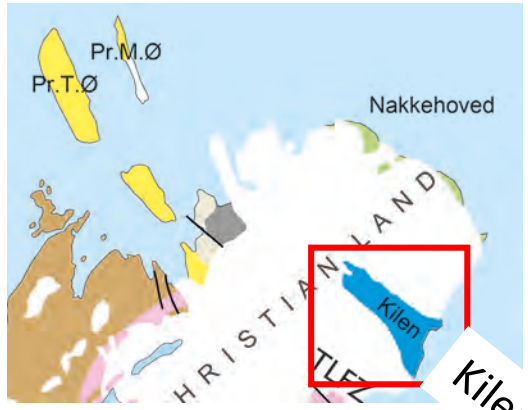
Palaeo-thermal proxies from VR and Tmax



Geological cross section

Pre-deformational restauration

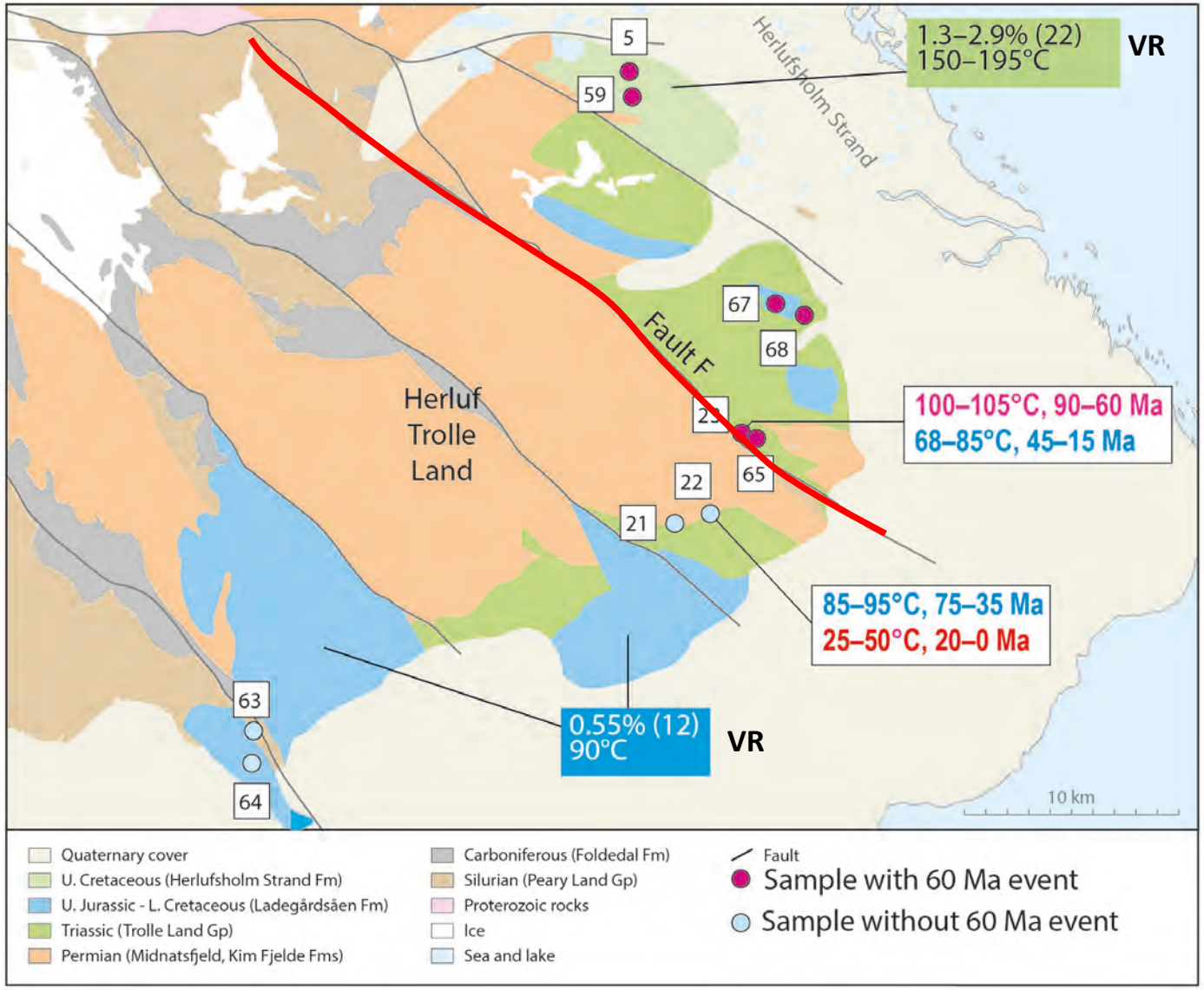






Pedersen et al. 2018; Svennevig et al. 2016

Palaeo-thermal constraints, Herluf Trolle Land (Trolle Land Fault Zone)

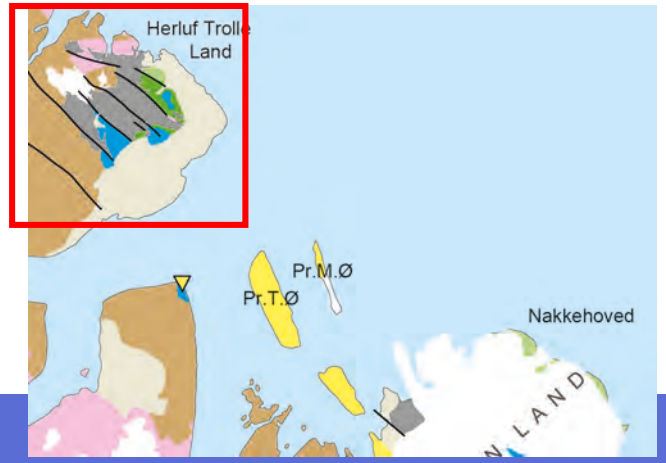


High VR values north of Fault 'F'

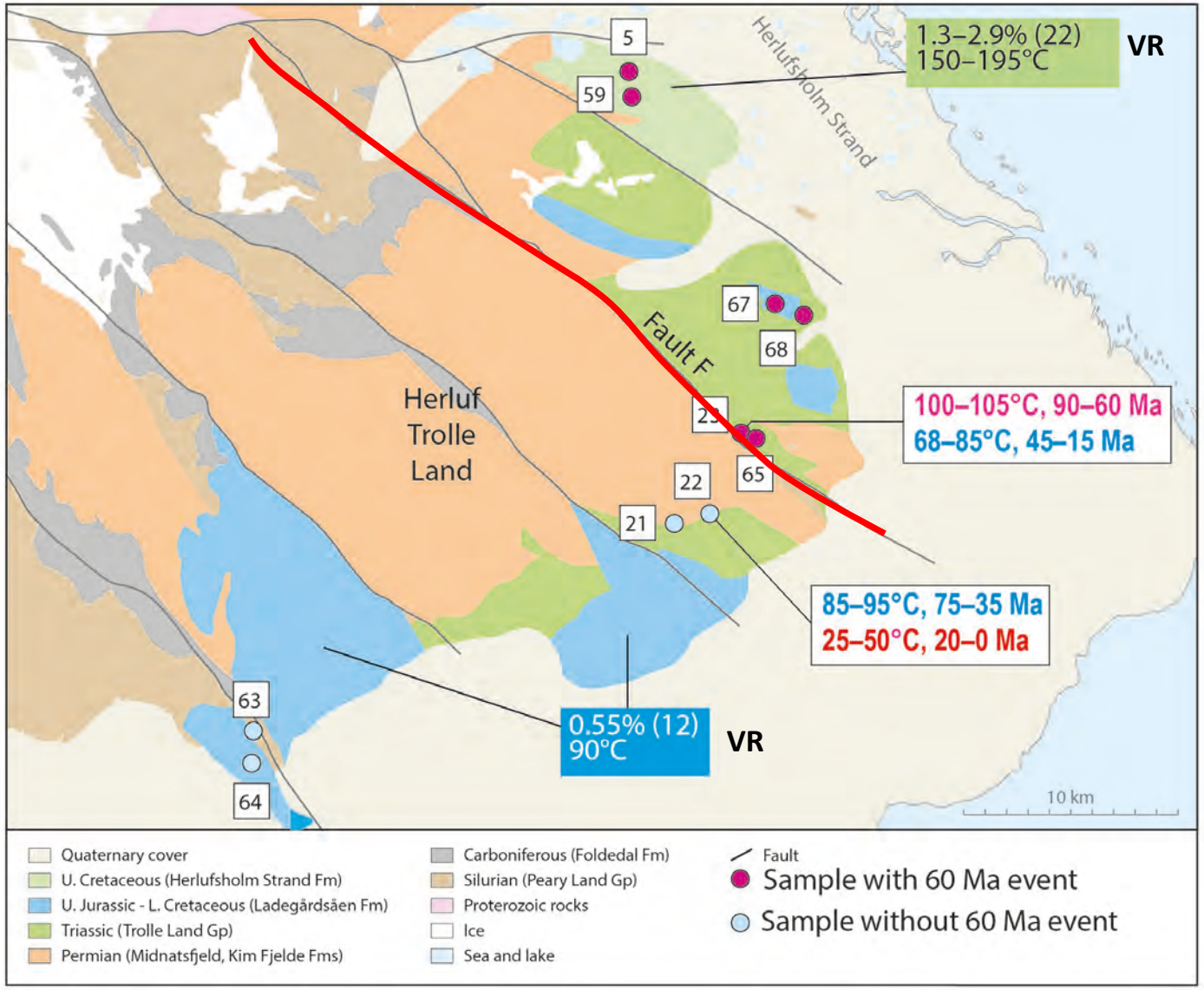
>100°C north of Fault 'F' at ~60 Ma

~80-90°C were reached at ~35 Ma

VR: Vitrinite reflectance



Palaeo-thermal constraints; Herluf Trolle Land (Trolle Land Fault Zone)

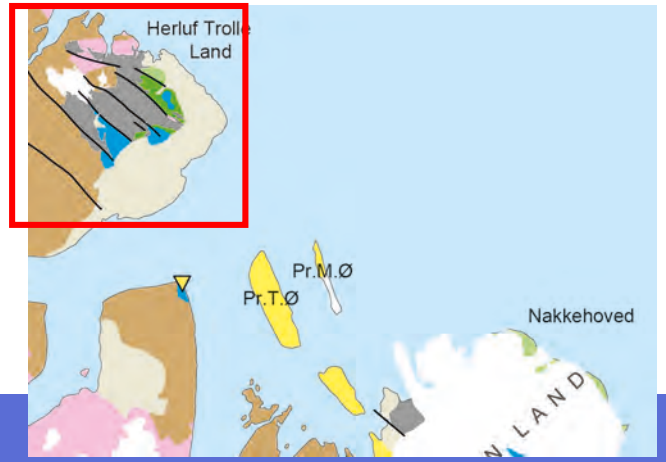


High palaeotemperatures prior to rift inversion at ~60 Ma

Mid-Paleocene inversion due to the onset of the Eurekan Orogeny

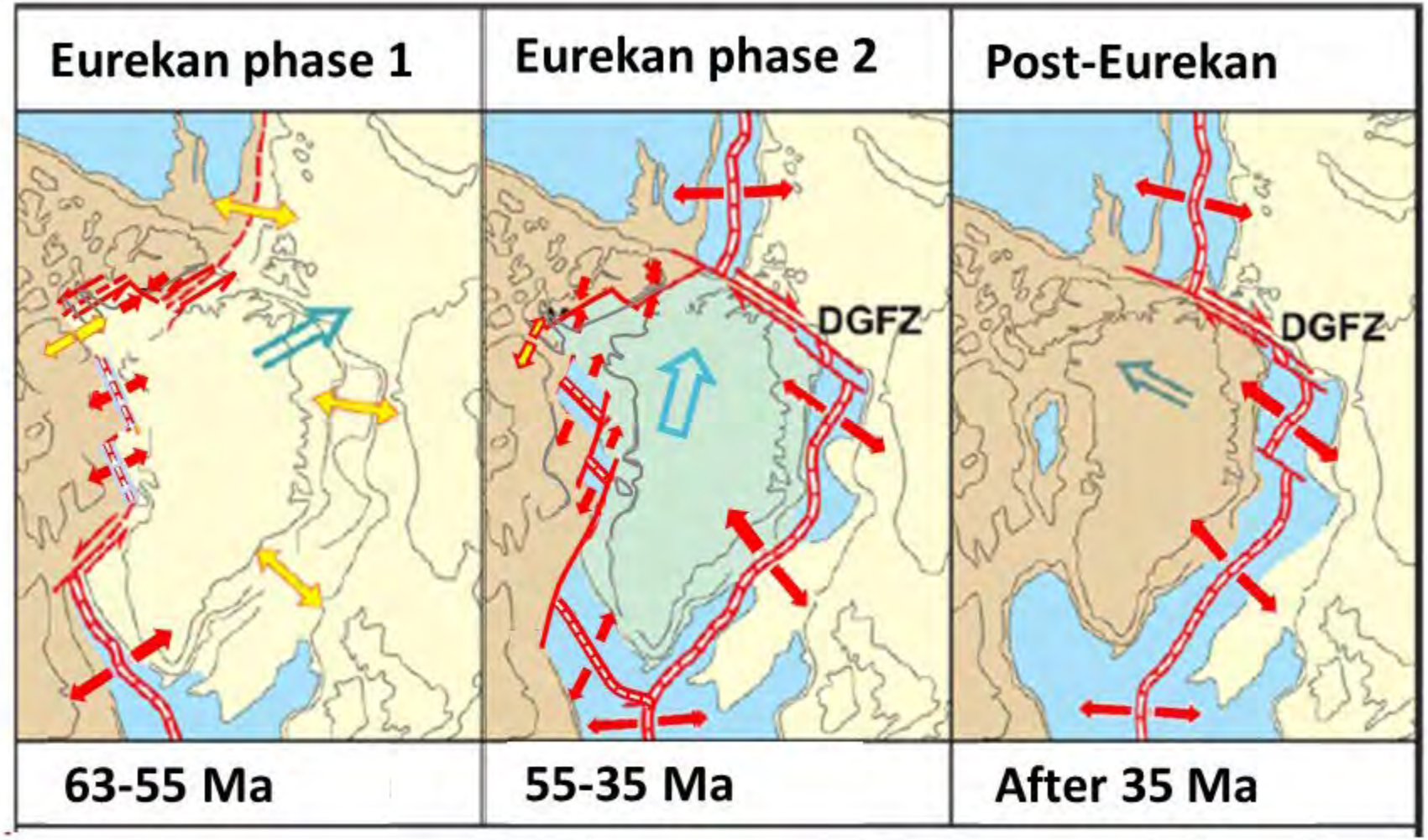
cf. Jones *et al.* 2017

VR: Vitrinite reflectance



Regional exhumation at 35 Ma vs the Eurekan Orogeny

Eurekan deformation NE and NW of Greenland



Extension

Relative movement of the Greenland plate

Active mid-ocean ridge sea-floor spreading

Compression

DGFZ: De Geer Fracture Zone

After Piepjohn et al. 2016; Oakey & Chalmers 2012

End-Eocene changes

35 Ma / Chron 13

- Cessation of sea-floor spreading between America and Greenland
- Jump of spreading ridges in the NE Atlantic
- Minimum spreading rates in the NE Atlantic



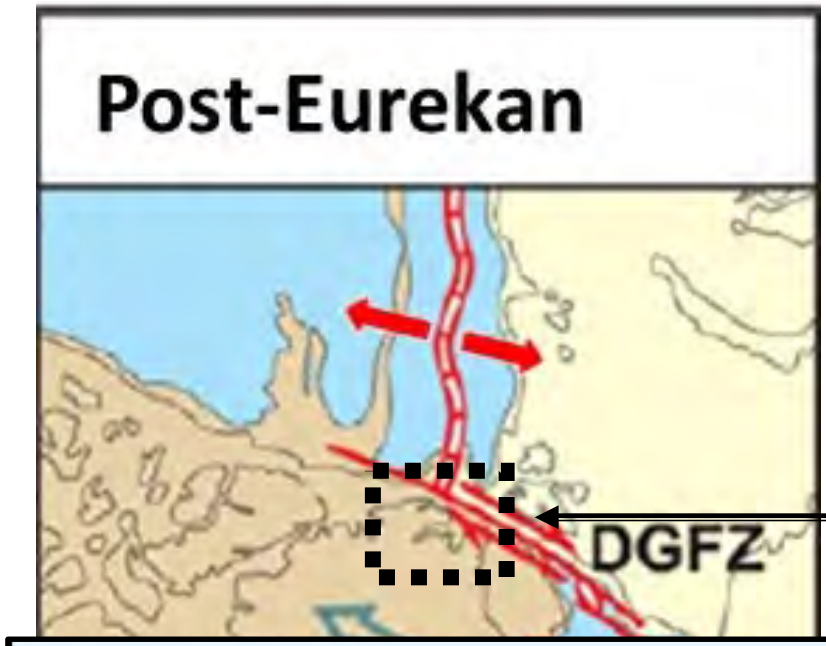
DGFZ: De Geer Fracture Zone

Oakey & Chalmers 2012, Gaina et al. 2018

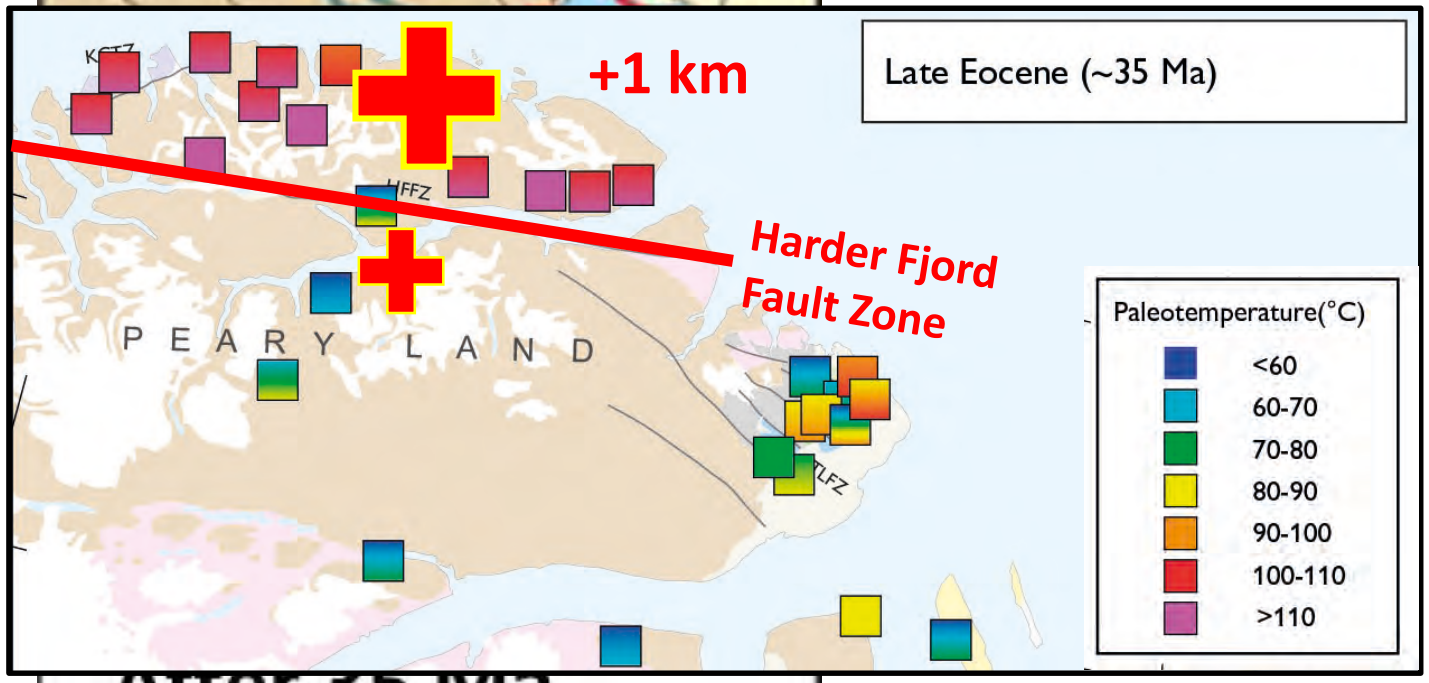
End-Eocene changes

35 Ma / Chron 13

- Cessation of sea-floor spreading between America and Greenland
- Jump of spreading ridges in the NE Atlantic
- Minimum spreading rates in the NE Atlantic
- Peary Land: reverse faulting



Peary Land



After 35 Ma

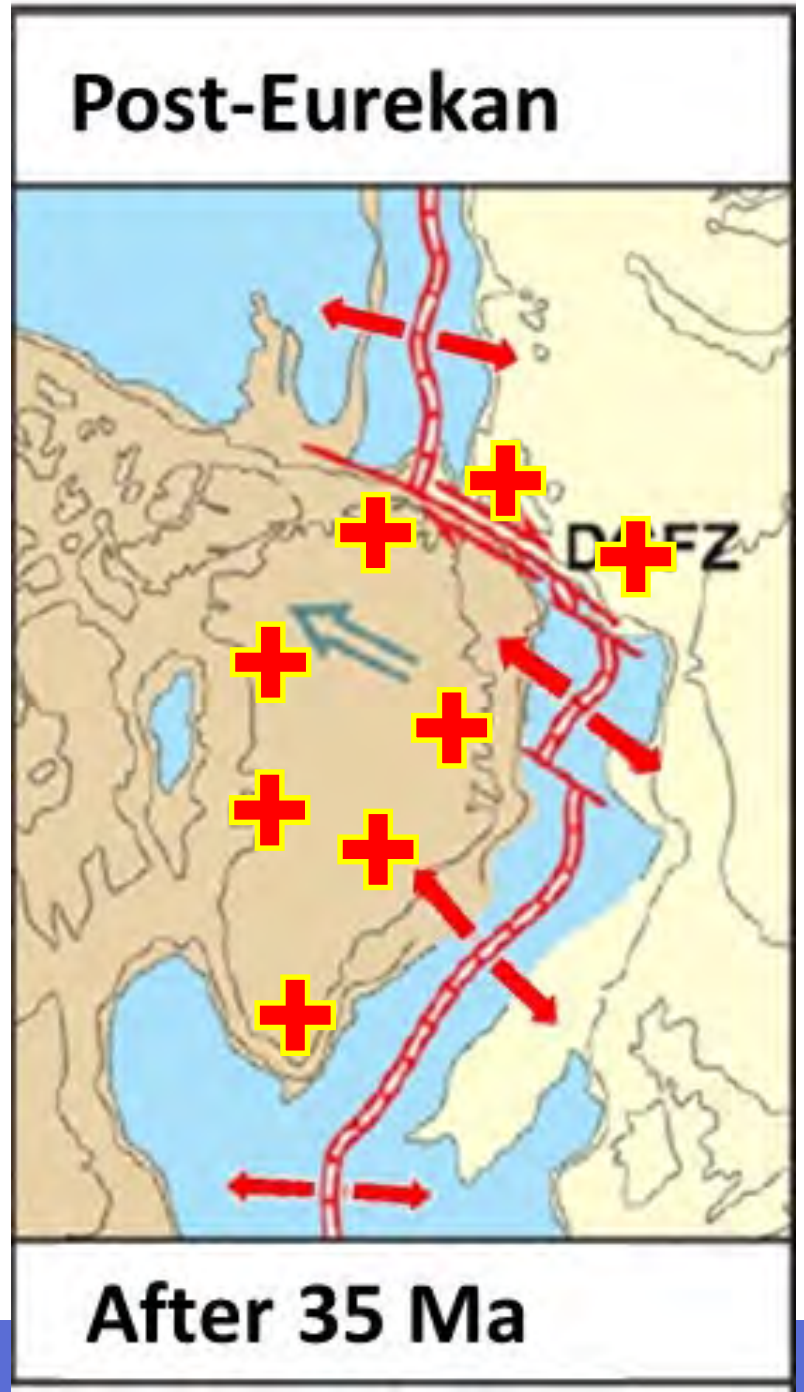
DGFZ: De Geer Fracture Zone

End-Eocene *compression*

35 Ma / Chron 13

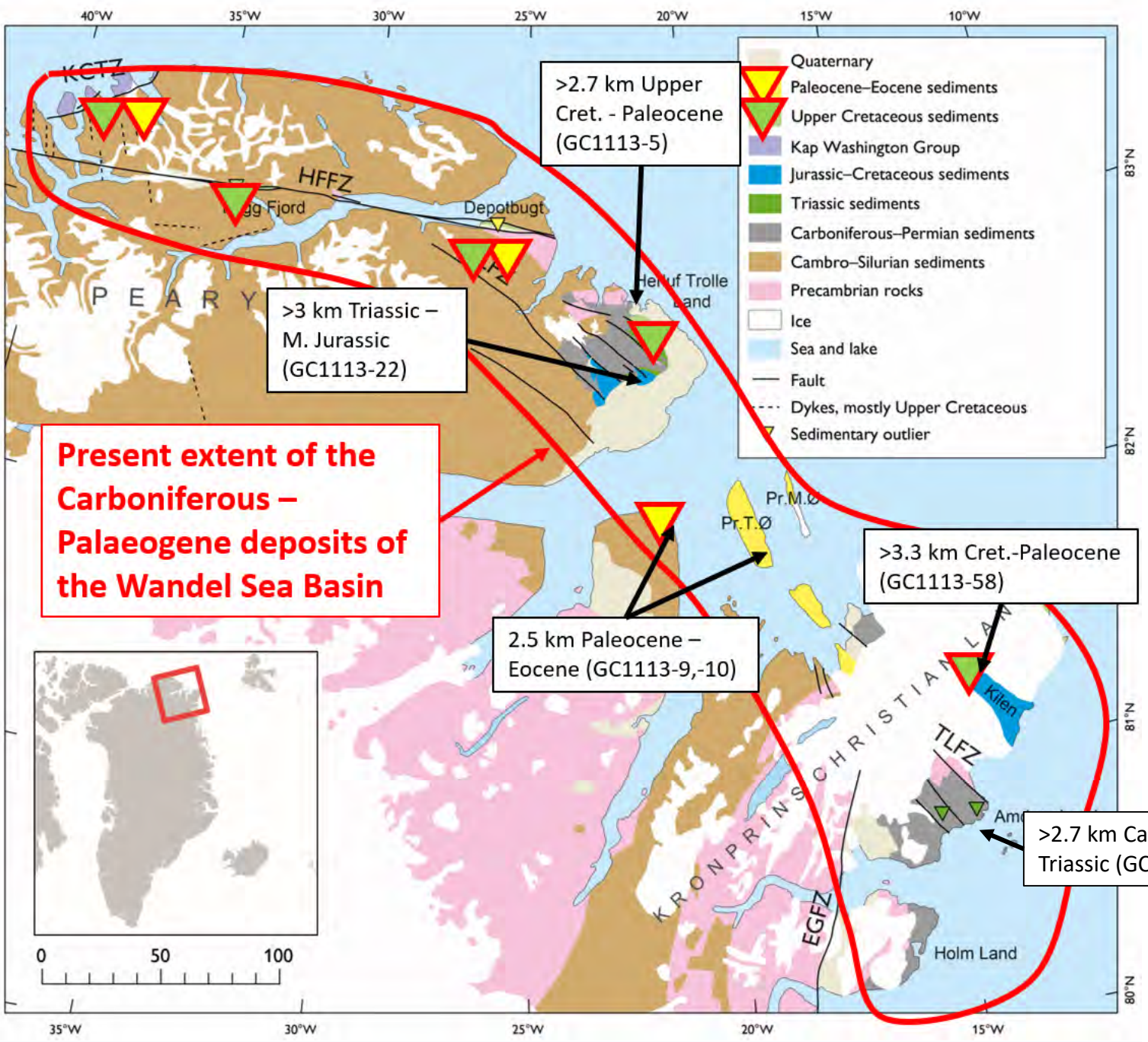
- Cessation of sea-floor spreading between America and Greenland
- Jump of spreading ridges in the NE Atlantic
- Minimum spreading rates in the NE Atlantic
- Peary Land: +1 km uplift, reverse

✚ End-Eocene uplift based on AFTA data



Expansion of the Iceland Plume began at 35 Ma
(Parnell-Turner et al. 2014)

Conclusions



The now isolated components of the Wandel Sea Basin were once parts of a more extensive depositional system.

In particular, inversion at 60 Ma removed much of the larger systems.

The Wandel Sea Basin may at times have been coherent with the Carboniferous–Palaeogene basins in North-East Greenland, Svalbard and the Barents Sea.

This is supported by recent sedimentological and stratigraphic studies (Hovikoski et al. 2018; Bjerager et al. 2019).

Two distinct phases of Paleogene exhumation

- **Mid-Paleocene exhumation of major fault zones**
- The exhumation defines the onset of inversion
- >3 km of Cretaceous-Paleocene sediments removed within the fault zones
- The inversion reflects the onset of the Eurekan Orogeny

- **Regional end-Eocene exhumation** affected the basin and surrounding regions
- ~2.5 km of Paleocene-Eocene sediments were removed across a wide area
- End-Eocene denudation and faulting represent a post-Eurekan tectonic phase
- A major plate reorganisation in the NE Atlantic took place at the same time