[PS]East Greenland: A Classic Example of an Elevated, Passive Continental Margin Shaped Long after Rifting and Breakup*

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Abstract

The Atlantic margin of East Greenland shares the characteristics of many elevated, passive continental margins around the world: Elevated plateaux (large-scale, low-relief and high-level landscapes) at 2 km or more above sea level (a.s.l.) cut by deeply incised valleys, Mesozoic-Cenozoic rift systems parallel to the coast, and a transition from continental to oceanic crust farther offshore. Other examples of such margins are found in SE Australia, Brazil, and Norway.

Breakup of the North Atlantic occurred at the Palaeocene-Eocene transition. The geological record in the Kangerlussuaq-Blosseville Kyst area (68-70°N) in SE Greenland shows that the area underwent short-lived uplift immediately prior to breakup followed by km-scale subsidence during the eruption of basalts, with no evidence for crustal upwarping at this time. The earliest basalts erupted partly in a marine environment, and there are marine incursions in the uppermost of the flood basalts. These Palaeogene lavas make-up Gunbjørn Fjeld which is the highest summit in Greenland (3.7 km a.s.l.), and the present topography is thus the result of post-rift uplift.

We have mapped the plateaux surfaces over a wide area in SE Greenland and find that they are erosion surfaces that truncate both Palaeogene basalts and older rocks. Consequently, these surfaces (or peneplains) are post-basalt in age, and we suggest that they formed by fluvial erosion towards the base level of the adjacent sea during the opening of the North Atlantic. The present topography thus formed in two steps: first by erosion to form a peneplain near sea level and second by uplift to form a high plateau. The present topography has developed by incision of this high plateau, initially by rivers and later by glaciers below the uplifted peneplain.

Many apatite fission-track (AFT) studies have been published from East Greenland, and we present new results from 100 samples from the

Kangerlussuaq area. Both published and new AFT data reveal that regional, Cenozoic cooling of the margin started at the Eocene-Oligocene transition. Post-rift subsidence and burial of the margin therefore lasted for about 20 Myr until uplift of the margin at the Eocene-Oligocene transition (c. 35 Ma). Uplift and erosion at this time affected margins around the North Atlantic, and because it also correlates in time with a major plate reorganisation in the region, we suggest that it was related to plate-tectonic forces. Because the regional cooling starting at 35 Ma coincides in space with the post-basalt pen plain, we find that the peneplain along the margin was the end-result of this episode of uplift and erosion. The new AFT data from SE Greenland also show that the peneplain was uplifted to its present elevation in the late Neogene, and thus that the shaping of the present topography began several tens of millions of years after breakup.

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East Greenland: A classic example of an elevated, passive continental margin shaped long after rifting and breakup

Mountain building and Ice-Sheet Stability in Greenland (Miss Green), 2008 - 2011

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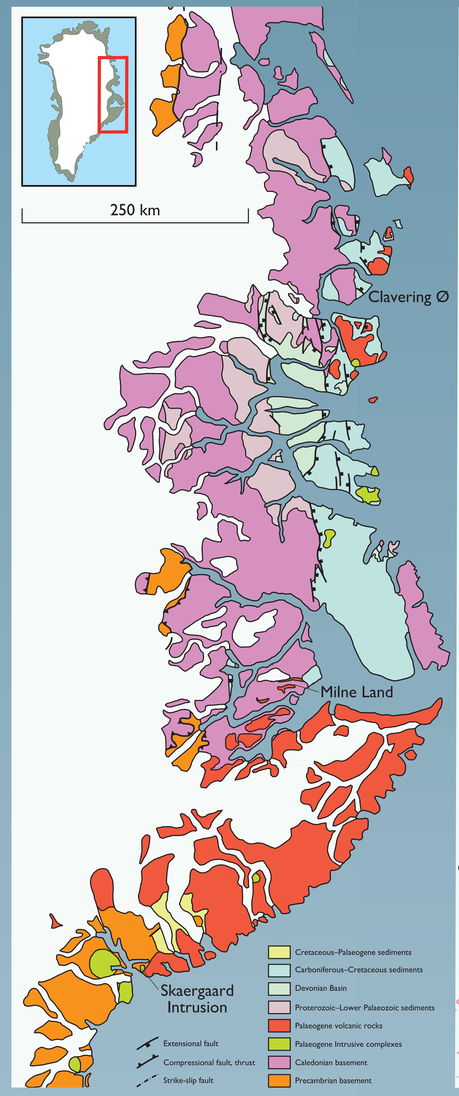
The mountains in East Greenland are not the erosional remains of a former orogen. The mountains extend well beyond the Caledonian orogen and contain rocks formed from the Precambrian to the Palaeogene



East Greenland – a typical elevated, passive continental margin

• Elevated plateaux at 2 km or more a.s.l. that are cut by deeply incised valleys

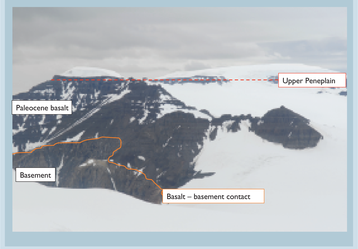
• Mesozoic-Cenozoic rift systems parallel to the coast

• A transition from continental to oceanic crust further offshore.

Other examples of such margins are found in SE Australia, Brazil and Norway

The Upper Peneplain, Milne Land

The Upper Peneplain, Milne Land
The peneplain is younger than the Palaeogene basalts



Present topography - result of post-rift uplift

The geological record in SE Greenland shows:

• That the area underwent short-lived uplift immediately prior to breakup (56 Ma)

• That the area underwent km-scale subsidence during the subsequent eruption of basalts

• No evidence for crustal upwarping at this time

• Partly marine environment during the eruption of the earliest and the youngest flood basalts.

These Palaeogene lavas make up the highest summit in Greenland.

Burial of the Skaergaard intrusion below c. 5 km flood basalts during 300.000 years at 56 Ma

The highest summit in Greenland is made up by Palaeogene basalts that were erupted during subsidence

Regional peneplain formed after uplift event at 35 Ma

Published and new apatite fission-track data from East Greenland show:

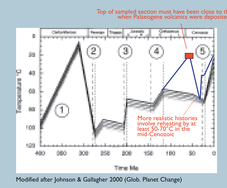
• Post-rift subsidence and burial of the margin therefore lasted for c. 20 Myr, from breakup till c. 35 Ma

• Regional cooling of the margin started at the Eocene–Oligocene transition, c. 35 Ma

• The post-basalt peneplain along the margin was the end-result of this episode of uplift and erosion

Uplift and erosion at 35 Ma affected margins around the North Atlantic during a major plate reorganisation

Thermal history solutions for a vertical section of rocks on Clavering Ø



Modified after Johnson & Gallagher 2000 (Glob. Planet Change)

Re-interpretation obtained by incorporating the presence of the Palaeogene basalts above the section sampled by Johnson & Gallagher (2000)

• The uppermost sample must have been at near-surface temperature in the Palaeogene

• This implies re-burial prior to the onset of cooling from the mid-Cenozoic palaeothermal peak of c. 70°C

The alternative cooling history indicated is based on two episodes of cooling at c. 35 and 10 Ma (Thomson *et al.* 1999)

The peneplain was uplifted to its present elevation after 10 Ma

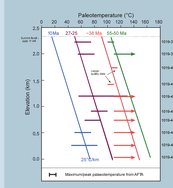
New apatite fission-track analysis (AFTA) data from SE Greenland show:

• Palaeotemperatures for rocks now at sea level were 50-60°C at 10 Ma due to km-scale burial

• The post-basalt peneplain and the present-day summits were uplifted to their present elevation in the late Miocene, after 10 Ma

The shaping of the present topography began several tens of millions of years after breakup by incision below the uplifted peneplain

Cathedral Mountain: Palaeothermal constraints estimated from AFTA data along a vertical transect



Section of rock above the summit

Profiles drawn with palaeo-gradient of ~25°C/km.

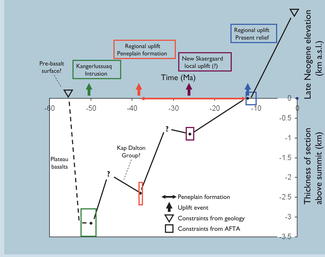
>3 km of section in the Early Eocene (55-50 Ma)(summit intercept of 110°C)

At 38 Ma, c. 3 km (summit intercept ~90°C)

At ~26 Ma c. 1.2 km at the start of the Miocene (summit intercept ~50°C)

At the onset of Late Miocene cooling, there was probably no section above the summit, and that is when incision of the present-day relief started!

Possible burial and exhumation history of the summit of Cathedral Mountain

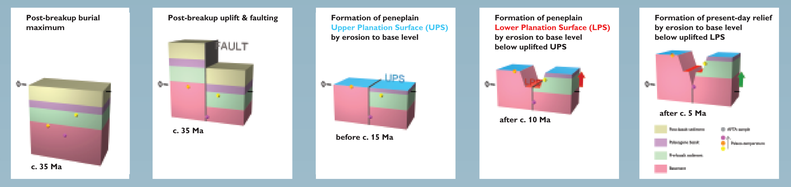


The present topography formed in two main steps:

• First by erosion to form a peneplain near sea level

• Second by uplift to form a high plateau

The uplift of the plateau took place in two phases



Faults, erosion surfaces and palaeothermal data may reveal events that happend after the deposition of the youngest strata

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