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Cenozoic uplift of Nuussuaq and Disko, West Greenland—elevated erosion surfaces as uplift markers of a passive margin

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Abstract

Remnants of a high plateau have been identified on Nuussuaq and Disko, central West Greenland. We interpret the plateau as an erosion surface (the summit erosion surface) formed mainly by a fluvial system and graded close to its former base level and subsequently uplifted to its present elevation. It extends over 150 km east–west, being of low relative relief, broken along faults, tilted westwards in the west and eastwards in the east, and having a maximum elevation of ca. 2 km in central Nuussuaq and Disko. The summit erosion surface cuts across Precambrian basement rocks and Paleocene–Eocene lavas, constraining its age to being substantially younger than the last rift event in the Nuussuaq Basin, which took place during the late Maastrichtian and Danian. The geological record shows that the Nuussuaq Basin was subjected to subsidence of several kilometres during Paleocene–Eocene volcanism and was transgressed by the sea later during the Eocene. By comparing with results from apatite fission track analysis and vitrinite reflectance maturity data, it is suggested that formation of the erosion surface was probably triggered by an uplift and erosion event starting between 40 and 30 Ma. Surface formation was completed prior to an uplift event that started between 11 and 10 Ma and caused valley incision. This generation of valleys graded to the new base level and formed a lower erosion surface, at most 1 km below the summit erosion surface, thus indicating the magnitude of its uplift. Formation of this generation of valleys was interrupted by a third uplift event also with a magnitude of 1 km that lifted the landscape to near its present position. Correlation with the fission-track record suggests that this uplift event started between 7 and 2 Ma. Uplift must have been caused initially by tectonism. Isostatic compensation due to erosion and loading and unloading of ice sheets has added to the magnitude of uplift but have not significantly altered the configuration of the surface. It is concluded that the elevations of palaeosurfaces (surfaces not in accordance with present climate or tectonic conditions) on West Greenland's passive margin can be used to define the magnitude and lateral variations of Neogene uplift events. The striking similarity between the landforms in West Greenland and those on many other passive margins is also noted.

Keywords: Landform analysis; Erosion surface; Glaciation; Neogene; Passive continental margin; Uplift; West Greenland

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1. Introduction

The timing and amount of Cenozoic uplift and erosion along the passive margins around the North Atlantic are a topic of debate (Japsen and Chalmers, 2000; Doré et al., 2002; Fig. 1). Early geomorphologists such as Reusch (1901) and Ahlmann (1919) suggested that erosion surfaces at high altitude in Scandinavia are indications of late Cenozoic uplift. Their conclusion is supported by recent studies of truncated Neogene sediments offshore (e.g. Jensen and Schmidt, 1992; Fig. 1). Attempts have also been made to correlate the offshore geology with onshore erosion surfaces, but correlations have proven difficult as no Mesozoic or Palaeogene rocks are preserved in the Scandinavian highlands (Doré, 1992; Riis, 1996; Lidmar-Bergström, 1999; Lidmar-Bergström et al., 2000).

For a long time, the usefulness of erosion surfaces as markers for uplift events has been queried after heavy criticism from, for example, Chorley (1963) and later by Summerfield (2000). A recent representative discussion of this type of criticism is by Brown et al. (2000) who rejected the interpretation by King (1967, 1976) that the stepped surfaces on the passive margins of South Africa and South America represent planation surfaces that have been uplifted by several tectonic events after rifting. The criticism in Brown et al. (2000) and by others emphasises that such uplifted surfaces cannot be constrained by datable strata and that they therefore cannot be used as evidence for post-rift uplift. We would like to point out that absence of evidence is not evidence of absence and that it is possible to construct a relative event chronology from *landform analysis* that can be used to decipher the origin and magnitude of tectonic events and, when independent data are available, the absolute timing can be constrained (de Brum-Ferreira, 1991; Hall, 1991; Demoulin, 1995; Peulvast et al., 1996; Huguet, 1996; Twidale, 1999; Hall and Bishop, 2002; Lidmar-Bergström and Näslund, 2002; Demoulin, 2003; Fjellanger and Etzelmüller, 2003; Huguet, 2004; Peulvast and Claudino Sales, 2004; Schoenbohm et al., 2004; Clark et al., 2005; Kuhlemann et al., 2005).

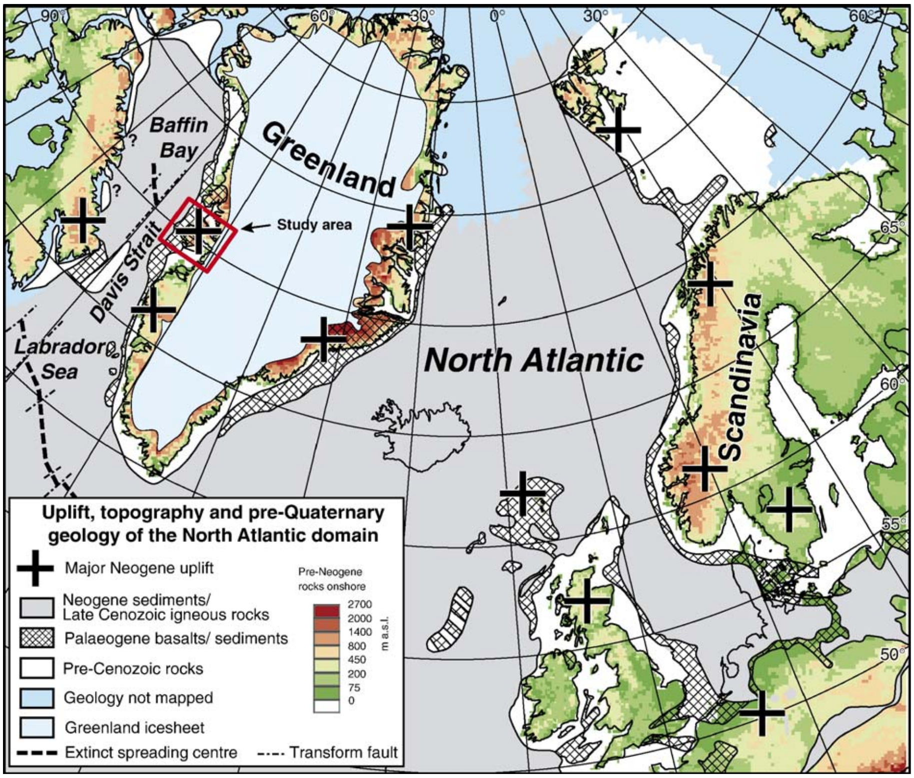

Fig. 1. Areas of Neogene uplift around the North Atlantic according to Trettin (1991) and Bonow et al. (in press) and studies referenced by Japsen and Chalmers (2000). The ages of the sediments below the Quaternary deposits increase towards the continents where pre-Cenozoic rocks are commonly exposed. This structural configuration is consistent with Neogene uplift of the continents. Note the position of the study area at an uplifted margin. Topography extracted from 2-min data (ETOPO-2). Geology modified after Jackson et al. (1992), Wheeler et al. (1996) and Japsen and Chalmers (2000).