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Episodic burial and exhumation of the southern Baltic Shield: Epeirogenic uplifts during and after break-up of Pangaea

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ABSTRACT

Cratons are conventionally assumed to be areas of long-term stability. However, whereas Precambrian basement crops out across most of the Baltic Shield, Palaeozoic and Mesozoic sediments rest on basement in southern Sweden, and thus testify to a complex history of exhumation and burial. Our synthesis of published stratigraphic landscape analysis and new apatite fission-track analysis data reveals a history involving five steps after formation of the extremely flat, Sub-Cambrian Peneplain. (1) Cambrian to Lower Triassic rocks accumulated on the peneplain, interrupted by late Carboniferous uplift and exhumation. (2) Middle Triassic uplift removed the Palaeozoic cover along the south-western margin of the shield, leading to formation of a Triassic peneplain with a predominantly flat relief followed by deposition of Upper Triassic to Lower Jurassic rocks. (3) Uplift that began during the Middle Jurassic to earliest Cretaceous caused denudation leading to deep weathering that shaped an undulating, hilly relief that was buried below Upper Cretaceous to Oligocene sediments. (4) Early Miocene uplift and erosion produced the South Småland Peneplain with scattered hills. (5) Early Pliocene uplift raised the Miocene peneplain to its present elevation leading to reexposure of the sub-Cretaceous hilly relief near the coast. Our results thus provide constraints on the magnitude and timing of episodes of deposition and removal of significant volumes of Phanerozoic rocks across the southern portion of the Baltic Shield. Late Carboniferous, Middle Triassic and mid-Jurassic events of uplift and exhumation affected wide areas beyond the Baltic Shield, and we interpret them as epeirogenic uplifts accompanying fragmentation of Pangaea, caused by accumulation of mantle heat beneath the supercontinent. Early Miocene uplift affected north-west Europe but not East Greenland, and thus likely resulted from compressive stresses from an orogeny on the Eurasian plate. Early Pliocene uplift related to changes in mantle convection and plate motion affected wide areas beyond North-East Atlantic margins.

1. Introduction

Cratons are widely regarded as the stable interiors of continents, including both shields where basement rocks crop out extensively, and platforms where horizontal or subhorizontal sediments rest on the basement. Many studies, however, provide evidence that cratonic areas have been far from stable over Phanerozoic time, and have undergone repeated episodes of subsidence and uplift, during which kilometre-scale thicknesses of rock are deposited and removed: much of the evidence in support of this behaviour comes from thermochronology studies in shield regions; e.g. mid-continent USA (Flowers and Kelley, 2011), western Australia (Weber et al., 2005) and Canada (Ault et al., 2013). Stratigraphic landscape analysis also provides evidence of uplift and subsidence in shield areas, using cross-cutting relationships between peneplains – large-scale, low-relief surfaces produced by erosion to base level – and stratigraphic constraints on the sedimentary cover which preserved them, to construct a relative chronology for surface formation and tectonic events (Lidmar-Bergström et al., 2013). Here we adopt this broad definition of peneplains as the general term for extensive, low-relief erosion surfaces (hilly or flat), graded to distinct base levels (see discussion in section 3.2.2 of Green et al., 2013).

Precambrian crystalline basement dominates the Baltic Shield that extends across Sweden and Norway (outside the mid-Silurian–early Devonian Scandinavian Caledonides), Finland and north-westernmost Russia (Eugeno S Working-Group, 1988). Few remnants of Phanerozoic cover rocks are present on most parts of the shield apart from Quaternary deposits. However, Palaeozoic and Mesozoic sediments rest on the basement in the south-western part of the shield (Fig. 1),

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documenting a complex Phanerozoic history of exhumation and burial. Lidmar-Bergström (1988, 1993) used the relations between these cover rocks and distinct peneplains across the Precambrian basement of the south-western Baltic Shield to define the evolution of the South Swedish Dome (up to 400 m above sea level, a.s.l.) through multiple Phanerozoic episodes of burial and subsequent exhumation.