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Mesozoic crustal architecture defines Scandinavia's present-day geomorphology

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The Scandinavian extended margin exhibits statistically robust geometric relationships between today's landscape and structures that were created during both crustal thinning/exhumation phase extension and the final continental breakup. The present-day maximum elevations of more than 175 cross sections are directly proportional to the length of a two-dimensional beam defined on one end by severely thinned crust (the taper break), and on the other by the onset of the hinterland topographic rise. The R2 correlation coefficient is 0.78. A sharp gradient in effective elastic lithospheric thickness near the hinterland break-in-slope functions as a tectonic hinge point, about which the beam is upwardly deflected. Hinterland dip angles and river drainage patterns are also governed by crustal thinning architecture: dip magnitudes are proportional to the beam length and mean hinterland dip azimuths are statistically identical to the direction of kinematic transport recovered from escarpment parallel, onshore normal faults and their brittle fault rocks. Many such onshore normal faults are related to fabrics inherited from the thinning phase, or even before, and were reactivated in post-thinning phase time. Some faults appear to be active today. The role of structural inheritance in the evolution of Scandinavian landscapes has been hitherto severely underestimated.

The post-breakup Scandinavian Mountains are not anomalous. Similar escarpments adorn many of the world's extended margins; they too obey a simple scaling law. These two observations strongly suggest that external forces such as ridge push, mantle diapirs, or edge-driven convection are not by themselves important topographic drivers. Rather, 'passive margin' escarpments appear to be primarily controlled by processes related to rifting and breakup. Our Scandinavian results suggest that a mechanically weakened zone lying between true oceanic crust and the taper break – the Continent Ocean Transition (COT) - functions as the nearly-but-not-quite broken edge of a flexed thin lithospheric plate. Within this conceptual model the Scandinavian Mountains exist as a whole in a stable state of regional isostasy, with episodic rock column uplift driven by mass transfer through erosion and deposition. We suggest that the COT is a severely weakened zone that lost its structural integrity during Mesozoic crustal thinning. The underlying offshore Lower Crustal Body may be a product of the rift process itself: nearly-but-not-quite-exhumed serpentinized mantle dating from the pre-breakup exhumation phase of Scandinavian extension. Taper and load effects may comprise a positive feedback on many passive margins, consistent with repeated exhumation in the areas that were most uplifted in the syn-rift phase, and also consistent with repeated or long-lasting sediment input from the same catchment systems. Whilst thermal effects and climatic changes may affect rates and magnitude of uplift, the shape and localization of uplift appears to be pre-determined by thinning-phase normal faults, and, in some areas affected by post-rift normal faults. For passive margins in general, the implications with respect to drainage evolution and landscape formation, and the associated erosion, transport and deposition of sediments, are profound.