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Crustal thinning and topography at passive continental margins

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There is a relationship between crustal thinning patterns and onshore topography at passive continental margins. This relationship appears to be governed principally by the crustal thinning gradient (taper) of the crystalline crust from unrifted crustal thickness down to a thickness less than 10 km. Surprisingly, the relationship appears to hold for very long time intervals (> 150 ma) after rifting and breakup.

Offshore Norway, two end-member styles of crustal thinning are observed. Along the Møre margin, a basin-flank detachment complex thinned the crust dramatically from c. 40 to less than 10 km over a horizontal distance of < 100 km. Along the Trøndelag Platform, however, thinning down to less than 10 km was distributed between 2-3 large-magnitude normal faults over a much broader region, which evolved into platform and terrace areas. The location, displacement magnitude and lateral arrangement of faults that developed in the margin´s 'thinning´ phase governed the position of the proximal-distal margin boundary and thus the gross-scale thinning gradient, or taper, of the crystalline crust. In the onshore areas, the effects on topography, landscape and fault reactivation patterns are profound. The highest escarpment and the most asymmetric margin topography developed inboard of sharply tapering crystalline crust. Inboard of sharp tapers, strong landscape contrasts developed across lineaments that were reactivated after the main phase of Mesozoic rifting, but prior to the glaciations. Glacial erosion enhanced tectonically induced drainage patterns, resulting in an asymmetric landscape distribution with high-relief alpine topography preferentially developed on the footwall sides of reactivated faults. This, in turn, pre-destined these landscapes to increased rockslide susceptibility because in the deeply incised escarpment topography, glacial incision undercut structures that had been reactivated in the brittle mode.

The above relationships indicate that extensional faulting exerts a long-term control on escarpment topography, landscape contrasts, geohazard susceptibility and sediment routing patterns along passive margins, through the establishment of the taper. On more than 40 published profiles through passive margins, we have measured the distance from the taper break (where the crust is thinned to 10 km or less) to the point of maximum topographic elevation on the adjacent escarpment (apparent taper length) and plotted it against the maximum escarpment elevation measured on each profile. Our analysis indicates that breakup age, glaciations and calculated mantle effects are all subordinate to the taper in controlling escarpment topography. Also, substituting the taper break with the COB does not yield a particularly tight relationship. These observations indicate that it is the thinning of continental crystalline crust down to <10 km and not the replacement of continental with oceanic crust that matters for the topography of the escarpment. Moreover, sharp reductions in the thickness of crystalline crust from <30 km down to less than 10 km do not appear to produce long-standing escarpments.