Geophysical Research Abstracts
Vol. 15, EGU2013-1621, 2013
EGU General Assembly 2013

The Seismicity of Two Hyperextended Margins

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A seismic belt marks the outermost edge of Scandinavia's proximal margin, inboard of and roughly parallel to the Taper Break. A similar near- to onshore seismic belt runs along its inner edge, roughly parallel to and outboard of the asymmetric, seaward-facing escarpment. The belts converge at both the northern and southern ends of Scandinavia, where crustal taper is sharp and the proximal margin is narrow. Very few seismic events have been recorded on the intervening, gently-tapering Trøndelag Platform. Norway's distribution of seismicity is systematically ordered with respect to 1) the structural templates of high-beta extension that shaped the thinning gradient during Late Jurassic or Early Cretaceous time, and 2) the topographically resurgent Cretaceous-Cenozoic "accommodation phase" family of escarpments that approximate the innermost limit of crustal thinning [See Redfield and Osmundsen (2012) for diagrams, definitions, discussion, and supporting citations.]

Landwards from the belt of earthquake epicenters that mark the Taper Break the crust consistently thickens, and large fault arrays tend to sole out at mid crustal levels. Towards the sea the crystalline continental crust is hyperextended, pervasively faulted, and generally very thin. Also, faulting and serpentinization may have affected the uppermost parts of the distal margin's lithospheric mantle. Such contrasting structural conditions may generate a contrasting stiffness: for a given stress, more strain can be accommodated in the distal margin than in the less faulted proximal margin. By way of comparison, inboard of the Taper Break on the gently-tapered Trøndelag Platform, faulting was not penetrative. There, similar structural conditions prevail and proximal margin seismicity is negligible. Because stress concentration can occur where material properties undergo significant contrast, the necking zone may constitute a natural localization point for post-thinning phase earthquakes.

In Scandinavia, loads generated by escarpment erosion, offshore sedimentary deposition, and post-glacial rebound have been periodically superimposed throughout the Neogene. Their vertical stress patterns are mutually-reinforcing during deglaciation. However, compared to the post-glacial dome the pattern of maximum uplift/unloading generated by escarpment erosion will be longer, more linear, and located atop the emergent proximal margin. The pattern of offshore maximum deposition/loading will be similar. This may help explain the asymmetric expenditure of Fennoscandia's annual seismic energy budget. It may also help explain the obvious Conundrum: if stress generated by erosion and deposition is sufficiently great, fault reactivation and consequent seismicity can occur at any hyperextended passive margin sector regardless of its glacial history. Onshore Scandinavia, episodic footwall uplift and escarpment rejuvenation may have been driven by just such a mechanism throughout much of the later Cretaceous and Cenozoic.

SE Brasil offers a glimpse of how Norway's hyperextended margin might manifest itself seismically in the absence of post-glacial rebound. Compilations suggest two seismic belts may exist. One, offshore, follows the thinned crust of the ultra-deep, hyperextended Campos and Santos basins. Onshore, earthquakes occur more commonly in the elevated highlands of the escarpments, and track especially the long, linear ranges such as the Serra de Mantiquiera and Serra do Espinhaço. Seismicity is more rare in the coastal lowlands, and largely absent in the Brasilian hinterland. Although never glaciated since the time of hyperextension and characterized by significantly fewer earthquakes in toto, SE Brasil's pattern of seismicity closely mimics Scandinavia. Commencing after perhaps just a few tens of millions of years of 'sag' basin infill, accommodation phase fault reactivation and footwall uplift at passive margins is the inexorable product of hyperextension.

CITATIONS
Redfield, T.F. and P.T. Osmundsen, 2012, GSA Bulletin, doi: 10.1130/B30691.1