Geophysical Research Abstracts,
Vol. 11, EGU2009-5863, 2009
EGU General Assembly 2009

Crustal taper and post-rift uplift at passive margins

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We suggest that crustal architecture inherited from pre-breakup extension exerts a first-order control on the long-term persistence and/or rejuvenation of topography at passive margins. The gradient of crustal thinning, termed here the crustal taper, appears to constitute an important parameter. The taper break for the continental crust is defined here to be located where the crustal thickness has been reduced to a value of 10 km or less, corresponding approximately to the boundary between the proximal and distal margin as defined by other workers. In 32 published cross sections, out of which 23 are based on well-constrained deep seismic data, the ratio of the maximum onshore topographic elevation and the distance from that topography to the onset of crustal taper appears to closely follow a simple mathematical function. Our best empirical fit for all 32 margins follows an exponential function $z = 2.6998 \exp -0.0026x$ with correlation $R2 = 0.7927$, where z is the maximum topographic elevation and x is the distance from the highest topography to the taper edge. A subset of only glacial and post-glacial passive margins (11 samples) follows the function $z = 2.9873 \exp -0.00267x$ with correlation $R2 = 0.9312$. For Norway, the exponential relationship also holds when the distance to the Bouguer gravity low is used instead of the distance to the topographic high. For most of the margins, the relationship between taper and topography is such that the highest topographic elevations are found inboard of where crystalline crust tapers sharply over a short distance, from thicknesses of 30-40 km to less than 10 km. Where the tapering of the crystalline crust is more gradual, the topography inboard tends to rise less abruptly, and to lower maximum elevations. On the Mid Norway rifted margin, the taper of the crystalline crust is commonly defined by large-magnitude normal faults (basin-flank detachment faults) that were active in Late Jurassic-Early Cretaceous time and subsequently eroded, overstepped and abandoned in the Early to Late Cretaceous. The rejuvenation of topography in the post-rift phase was assisted by the reactivation of inherited structures onshore, and not commonly the structures that defined the crustal taper. This inboard migration of faulting was very likely associated with redistribution of positive (depositional) and negative (erosional) loads following the cessation of active rifting. Post-rift faulting has had a pronounced effect on the landscape evolution in Scandinavia, resulting in differential preservation of palaeolandscapes across reactivated faults and in the formation of high-relief alpine landscapes where glacial exploitation of the upthrown footwalls led to obliteration of pre-glacial landforms. That a positive correlation between elevation and taper exists in a global dataset suggests a certain commonality of post-rift process for all passive margins. That their maximum elevations follow a simple function suggests the hand of a limiting factor such as flexural rigidity. That glacial and post-glacial margins conform even more closely to an empirical function than their non-glacial cousins suggests that unloading due to relatively recent erosion is an important factor in post-rift topographic rejuvenation.