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Flow of material under compression in weak lower continental crust can cause post-rift uplift of passive continental margins

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There are mountain ranges up to more than 2 km high along many passive continental margins (e.g. Norway, eastern Australia, eastern Brazil, SE and SW Africa, east and west Greenland etc.), dubbed Elevated Passive Continental Margins (EPCMs). EPCMs contain several features in common and observations indicate that uplift of these margins took place after continental break-up. There are many explanations for their formation but none that satisfy all the observations. Lack of a geodynamical mechanism has meant that there has been difficulty in getting the community to accept the observational evidence.

Formation of a passive continental margin must take place under conditions of tension.
After rifting ceases, however, the margin can come under compression from forces originating elsewhere on or below its plate, e.g. orogeny elsewhere in the plate or sub-lithospheric drag. The World Stress Map (www.world-stress-mp.org) shows that, where data exists, all EPCMs are currently under compression.

Under sufficient compression, crust and/or lithosphere can fold, and Cloetingh & Burov (2010) showed that many continental areas may have folded in this way. The wavelengths of folding observed by Cloetingh & Burov (2010) imply that the lower crust is likely to be of intermediate composition; granitic lower crust would fold with a shorter wavelength and basic lower crust would mean that the whole lithosphere would have to fold as a unit resulting in a much longer wavelength. Continental crust more than 20 km thick would be separated from the mantle by a weak layer. However, crust less thick than that would contain no weak layers would become effectively annealed to the underlying strong mantle.

Under sufficient horizontal compression stress, material can flow in the lower weak layer towards a continental margin from the continental side. The annealed extended crust and mantle under the rift means, however, that flow cannot continue towards the ocean. Mid- and lower crustal material therefore accumulates in the proximal rift and rift margin, thickening them and lifting them by isostatic response to the thickening. Flow into the rift margin is opposed by uplift and folding of the upper, strong crust, which imposes an additional normal stress, until crust thickens no more. However, flow continues through this thickened crust, thickening and uplifting the area "downstream", so widening the thickened area. Flow and uplift can continue until a reduction in imposed far-field compressive stress causes a consequent large reduction in inflow, thereby 'freezing' the thickened crust in place. Erosion of the uplifted area will lead to further uplift of the uneroded material because of the isostatic response to the erosion.

Reference

Cloetingh, S. & Burov, E. 2010: Lithospheric folding and sedimentary basin evolution: a review and analysis of formation mechanisms. Basin Research 22, 1365–2117. doi:10.1111/j.1365-2117.2010.00490.x.