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A flexural explanation for passive margin escarpment migration

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Based on results from numerical models that couple surface processes, flexural isostasy, faulting, stretching of the lithosphere and the associated thermal effects, we conclude that escarpments created at rift flanks by mechanical unloading and flexural rebound do not endure through time as retreating escarpments in situations where the lower crust under the rift shoulder has been substantially stretched. In this case, the escarpment is rapidly eroded away to reappear at a water divide that forms landward of the initial escarpment in a position close to a secondary bulge created during the rifting event at a distance that essentially depends on the flexural rigidity of the upper crust. This scenario takes place when the pre-rift topography dips landward, otherwise the evolution of the escarpment is guided by any pre-existing inland water divide. We suggest that this mechanism applies to many different passive margins around the world.

In Southeastern Brazil, the Serra do Mar escarpment lays approximately 200 km from the offshore hinge zone. We propose that during the rifting phase the initial escarpment originated close to the hinge zone and, due to substantial thinning of the lower crust in this region together with flexural effects, an inland water divide formed. Later, the combination of erosion and differential thermal subsidence of the margin led to the disappearance of the coastal escarpment and to the growth of the inland water divide into the present-day Serra do Mar.

Another possible example is the rifted margins of the Gulf of Aden. The Yemeni margin is characterized by a coastal escarpment and an inland water divide sub-parallel to the coast, named the Hadhramaut Arch. A similar inland water divide is not observed in the Omani and Somali margins. Through our numerical model we show that it is possible that the Hadharamaut Arch originated during the rifting phase from the secondary bulge. The same model also explain why the inland water divide is not observed along the other margins of the Gulf of Aden, where crustal thinning is known to be different from the Yemeni margin.

The Southeastern Australia margin presents a double water divide pattern sub-parallel to the coast, similar to the Yemeni margin. However, geological and geophysical data suggest that the inland water divide is a pre-rift feature. We conclude that, in this case, the pre-existing inland water divide, and not the secondary bulge, persisted as a pinned divide through the margin's evolution, with the flexural response of the margin during rifting producing a peripheral subsidence between the two water divides and ultimately preserving the present-day morphology.