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Physical analogs that help to better understand the modern concepts on continental stretching, hyperextension and rupturing

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Three facts helped to establish a revolution in the understanding of how mega-continents stretch, rupture and breakup to form new continents and related passive margins: (1) the penetration of the distal portions of the Iberia-Newfoundland conjugate margins by several ODP wells (late 70's/early 80's), with the discovery of hyperextended crust and exhumation of lower crust and mantle between typical continental and oceanic domains, (2) field works in the Alps and in the Pyrenees that re-interpreted sedimentary successions and associated "ophiolites" as remnants of old Tethyan passive margins that recorded structural domains similar to those found in Iberia-Newfoundland, and (3) the acquisition of long and ultra-deep reflection seismic sections that could image for the first time sub-crustal levels (25-40 km) in several passive margins around the world. The interpretation of such sections showed that the concepts developed in the Iberia-Newfoundland margins and in the Alps could be applied to a great extent to most passive margins, especially those surrounding the North and South Atlantic Oceans. The new concepts of (i) decoupled deformation (upper brittle X lower ductile) within the proximal domain of the continental crust, (ii) of coupled deformation (hyperextension) in the distal crust and, (iii) of exhumation of deeper levels in the outer domain, with the consequent change in the physical properties of the rising rocks, defined an end-member in the new classification of passive margins, the magma-poor type (as opposed to volcanic passive margins). These concepts, together with the new reflection seismic views of the entire crustal structure of passive margins, forced the re-interpretation of older refraction and potential field data and the re-drawing of long established models. Passive margins are prime targets for petroleum exploration, thus, the great interest raised by this subject in both the academy and in the industry.

Interestingly enough, the deformation modes envisaged by Manatschal and Peron-Pinvidic in several works published in the last ten years, dealing with the development of conjugate rifted margins (stretching, thinning, hyperextension/exhumation, oceanization/breakup), can be found in physical analogs of geological nature and of mundane phenomena, in a much smaller scale than that of a continental rupture. Rocks strained and cut by normal faults, especially the brittle sedimentary rocks, display geometries and structural domains, which in turn were formed by the particular deformation modes, very similar to those published for the Norwegian, Angolan and Southeastern Brazilian margins. A non-geological and non-conventional physical analog is the everyday breakup of a chocolate bar. Given it is stuffed by a thick ductile filling and covered by a thin, brittle chocolate layer; it is incredible how such a common phenomenon can replicate the rupture and breakup of a mega-continent. Such physical analogs can be compared to ultra-deep seismic sections and raise a cloud of incertitude on the definition of hyperextension. Instead of representing the coupling of the deformation of the upper and lower crusts into a brittle mode, rather, hyperextension could correspond to their coupling into a plastic or, at least, into a semi-brittle mode, but not into an entirely brittle mode.