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Complex rifted margins explained by dynamical models of depth-dependent lithospheric extension

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Subsidence of rifted continental margins is explained by the isostatic response to lithospheric stretching, which leads to syn-rift tectonic subsidence followed by lithospheric cooling and long-term post-rift thermal subsidence. Despite the success of the Uniform Extension model, observations from some margins, including central South Atlantic, Exmouth Plateau, and central and north Atlantic, are not consistent with its predictions. For these distinctive margins, wide regions of extremely attenuated crust but relatively thin overlying syn-rift sediments with upper layers that were deposited in shallow seas, are more compatible with the Depth-Dependent Extension model. Although the kinematics of depth-dependent stretching are understood, the conditions favoring this style and the consequences for a complete rift zone in space and time require investigation. We show that dynamical models which lead to depth-dependent extension explain characteristic features of these margins. A template developed from the dynamical model results which divides margins into Proximal, Sag and Distal (P, S, D) zones is broadly compatible with observations from approximately conjugate South Atlantic margins. Key to reproducing the observed characteristics are decoupling between upper and lower parts of the lithosphere during stretching, contrasting wide and narrow extensional styles above and below the decoupling level, and progressive focusing of crustal extension toward the rift axis. This behavior explains the subsidence, sedimentation and deformation of the associated array of sedimentary basins, the origin and context of so-called ‘sag’ basins, and the reasons these basins are prone to shallow water evaporite deposition during the late syn-rift. Evaporite-bearing South Atlantic margins of this type have recently been sites of new giant hydrocarbon

discoveries. Conceptual and quantitative insight based on the model proposed here can help evaluate the overall hydrocarbon potential of these basins.