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Rifted Continental Margins: The Case for Depth-Dependent Extension

Huismans, R.S.[1], Beaumont, C.[2]
[1]Department of Earth Science, Bergen University, Bergen, Norway, Ritske.Huismans@uib.no
[2]Department of Oceanography, Dalhousie University, Halifax, Canada

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Even though many basic properties of non-volcanic rifted margins are predicted by uniform extension of the lithosphere, uniform extension fails to explain other important characteristics. Particularly significant discrepancies are observed at: 1) the Iberia-Newfoundland conjugate margins (Type I), where large tracts of continental mantle lithosphere are exposed at the seafloor; and at 2) ultra-wide central South Atlantic margins (Type II), where continental crust spans wide regions below which it appears that lower crust and mantle lithosphere were removed. Neither corresponds to uniform extension in which crust and mantle thin by the same factor. Instead, either the crust or mantle lithosphere has been preferentially removed during extension. We show that the Type I and II styles are respectively reproduced by dynamical numerical lithospheric stretching models (Models I-A/C and II-A/C) that undergo depth-dependent extension. In this notation A and C imply underplating of the rift zone during rifting by asthenosphere and lower cratonic lithosphere, respectively. We also present results for models with a weak upper crust and strong lower crust, Models III-A/C, to show that lower crust can also be removed from beneath the rift zone by horizontal advection with the mantle lithosphere. From the model results we infer that these Types I, II, and III margin styles are controlled by the strength of the mid/lower crust, which determines the amount of decoupling between upper and lower lithosphere during extension and the excision of crust or mantle. We also predict the styles of sedimentary basins that form on these margins as a test of the concepts presented.