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# The low-angle detachment paradigm: A successful concept to explain mantle exhumation and continental break-up at rifted margins?

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Low-angle normal faults are widely regarded as playing an important role in the development of rifted margins. However, how important are these structures, when and how do they form, and how well can they account for geological and geophysical observations made along rifted margins?

The study of rift-related detachment faults at the present-day Iberia-Newfoundland, and the ancient Western Pyrenees-Bay of Biscay and Alpine rifted margins shows that these structures are complex and can not be described as one simple low-angle detachment fault as commonly shown in the classical simple shear model. Our investigations suggest that extension at these rifted margins developed through a sequence of modes, initiating with distributed normal faulting that was followed by localization of the deformation in a conjugate system of upper crustal and lower crustal/mantle detachment faults. These detachment faults probably interacted and were decoupled along mylonitic shear zones in a quartz-rich middle crust. When the crust was thinned to less than 10 km, the whole crust became brittle and faults cut from the surface into mantle. Fluids penetrated and serpentinized the underlying mantle, modified the bulk rheology and changed the mode of deformation. At this stage, downward concave faults formed, exhumed the subcontinental mantle to the seafloor over tens to hundreds of kilometres, before magmatic and thermal processes were able to localize the strain and focus magma and extension within a spreading system. The superposition of these different deformation modes during rifting can explain the geological-geophysical observations

made along the Iberia-Newfoundland and Alpine Tethys margins and can be used to model successfully the dynamic evolution of the magma-poor South Atlantic margins.

In conclusion, low-angle detachment faults are observed at rifted margins, but they are by far more complex as previously suggested by the existing models. Detachment faults are polyphase structures that occur in the highly extended parts of magma-poor rifted margins. The formation of detachment faults seems to be strongly linked with the bulk rheological evolution of the extending lithosphere that depends on the initial composition, thermal structure, occurrence of fluids and magma and many other factors. How these factors control the processes and how they interact in time and space during rifting is, however, not yet understood and remains the subject of ongoing research.