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Asymmetry and heterogeneity of crustal structure at magma-poor rifted margins: distribution of extension in space and time

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Magma-poor rifted margins consistently show extreme crustal thinning accompanied by normal faulting, the serpentinization of the mantle beneath crust thinned to less than 8 ± 2 km, and the unroofing of a broad zone of mantle within the continent-ocean transition, accompanied by the development of detachment and other large-offset faults. This contribution shows that these observations are the logical result of the progressive extension of cool lithosphere away from thermal anomalies such as plumes. Key processes include the rheological evolution of the lithosphere, resulting in increased coupling between the upper and lower crust, and eventually the embrittlement of the entire crust, faults cutting into the mantle and its serpentinization. Increased coupling and the development of serpentine detachments predict the development of late stage asymmetry once the entire crust is brittle. Such detachments are imaged on some margins and inferred on others; analysis of the crustal structure across conjugate margins shows that these are approximately symmetric until this late stage. However, caution is urged in relating the asymmetry of margins to an asymmetric rifting process rather than to a simple focussing of simple late extension at one margin. The asymmetry between the Flemish Cap and West Galicia margins may for instance be explained by superposition of two symmetric phases of rifting, one centred on the Galicia Interior Basin and one centred on the line of final breakup. Further analyses of crustal structure show that depth-dependent stretching of the crust is completely insufficient to explain the discrepancy between the amount of the visible extension along faults and

the amount of crustal thinning. Instead this “extension discrepancy” may be related to the complex evolution of brittle deformation through multiple phases and styles of faulting, related to the changes in the rheological character and strength of the lithosphere as it is thinned.