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The extension discrepancy at rifted margins - evidence for a complex structural evolution

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Across rifted margins, the prerift continental crust thins from $\sim$ 30 km, reaching zero at the continent-ocean transition (COT) beyond which either oceanic crust or unroofed mantle forms top basement. However at most margins, the amount of extension measured from fault geometries (β_f typically < 1.25) is far less than that required to explain whole crustal and lithospheric thinning, deduced from crustal thickness (whole crustal β_c tending to ∞) and subsidence. This is the extension discrepancy. The two end-member explanations are crustal depth-dependent stretching (DDS) and unrecognised faulting. There are several problems in explaining the extension discrepancy through DDS. First, excess thinning of the lower 80% of the crust should somewhere be balanced by thickening of the same or by excess thinning of the upper 20%. Neither is observed. Second, the seismic velocity structure of conjugate margins provides no evidence for significant crustal DDS. Finally, lower crustal rocks are present (i.e. not removed by DDS) at the only deep margin where basement has been sufficiently sampled. An alternative explanation for the extension discrepancy is that not all the extensional faulting has been recognized ($\beta_f << \beta_{uc} \sim \beta_c$), perhaps related to the far greater extension undergone at margins than at rifts. Simple models demonstrate that increasing the amount of extension results in complex geometries, in which only the latest phase of faulting is likely to be interpreted, leading to a massive underestimation of the amount of extension. This may arise if faults rotate to low-angle and hence lock up to be replaced by new, steeper faults. Such polyphase faulting rapidly leads to complex geometries which are unlikely to be fully resolved. Extension may also be underestimated if the faults do not lock-up but continue to large-offset normal faults develop, sometimes termed top basement faults as they exhume large expanses of their footwall which subsequently forms top basement and which may be misinterpreted therefore as prerift top basement. Evidence for both types of unrecognised faulting can be seen in field exposures and can be inferred from seismic data at rifted margins.