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How do normal faults grow?

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Normal faulting accommodates stretching of the Earth's crust, and it is arguably the most fundamental tectonic process leading to continent rupture and oceanic crust emplacement. Furthermore, the incremental and finite geometries associated with normal faulting dictate landscape evolution, sediment dispersal and hydrocarbon systems development in rifts. Displacement-length scaling relationships compiled from global datasets suggest normal faults grow via a sympathetic increase in these two parameters (the 'isolated fault model'). This model has dominated the structural geology literature for >20 years and underpins the structural and tectono-stratigraphic models developed for active rifts. However, relatively recent analysis of high-quality 3D seismic reflection data suggests faults may grow by rapid establishment of their near-final length prior to significant displacement accumulation (the 'coherent fault model'). The isolated and coherent fault models make very different predictions regarding the tectono-stratigraphic evolution of rift basin, thus assessing their applicability is important. To-date, however, very few studies have explicitly set out to critically test the coherent fault model thus, it may be argued, it has yet to be widely accepted in the structural geology community. Displacement backstripping is a simple graphical technique typically used to determine how faults lengthen and accumulate displacement; this technique should therefore allow us to test the competing fault models. However, in this talk we use several subsurface case studies to show that the most commonly used backstripping methods (the 'original' and 'modified' methods) are, however, of limited value, because application of one over the other requires an a priori assumption of the model most applicable to any given fault; we argue this is illogical given that the style of growth is exactly what the analysis is attempting to determine. We then revisit our case studies and demonstrate that, in the case of seismic-scale growth faults, growth strata thickness patterns and relay zone kinematics, rather than displacement backstripping, should be assessed to directly constrain fault length and thus tip behaviour through time. We conclude that rapid length establishment prior to displacement accumulation may be more common than is typically assumed, thus challenging the well-established, widely cited and perhaps overused, isolated fault model.