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Application of Extensional Basin Evolution Models to Heterogeneous Crustal Settings: Insights from South Africa

Our understanding of the spatial and temporal evolution of extensional basins has increased significantly over the last few years. However, despite significant crustal heterogeneities in most rift settings, models assume nearly homogeneous crust and the influence of pre-existing tectonic fabrics on the evolution of extensional basins remains difficult to evaluate. Southern South Africa provides an unique setting to study the structural and sedimentological development of rift systems within heterogeneous continental crust because of the juxtaposition of pre-rift exposure and exceptionally high quality sub-surface seismic and well data.

Development of a seismic stratigraphic framework for three offshore sedimentary basins (Pletmos, Gamtoos, and Algoa) enables the structural and sedimentological evolution of the basins to be established. These frameworks reveal that, unlike most documented extensional basins, the three South African basins have sedimentation focused upon one or two large controlling faults (dimensions >100 km long and >12 km cumulative displacement) from an early syn-rift stage. There is no evidence of isolated depocentres, or of intra-basin faults progressively coalescing as predicted by fault growth models. Additionally, detailed structural analysis reveals an intimate link between the Permo-Triassic Gondwanian compressional fabric and subsequent Mesozoic extensional structures, associated with Gondwana break-up, showing that basin development is controlled by pre-existing structures. These observations require the re-evaluation of current fault growth models, and a new model to be proposed in which crustal heterogeneities result in very early strain localisation onto pre-existing structures. This strain localisation has a significant effect upon the structural and sedimentological development of extensional basins.