The Enigma of the 'Transition' Phase: How Rift Basins Evolve to Passive Margins

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ABSTRACT

At a first order our current models of lithospheric extension elegantly describe the processes by which rifting of the continental crust progressively evolves from incipient rifting, through rift climax, lithospheric necking and ocean crust formation into a passive margin basin. However, recent advances in the imaging quality, maximum recording time and line density of industry acquired seismic reflection across passive margins is increasingly challenging the validity of these models. In much of the South Atlantic the transition or sag phase has been well documented but its genesis and indeed geometry is poorly understood. In this study we use recently acquired data from the Orange Basin of Southern Africa and the Uruguay margin to consider the geometric evolution of this enigmatic phase. We investigate the evolution of the transition phase through an integrated approach of reflection interpretation, structural and stratigraphic analysis, backstripping, and gravity modelling. In addition, we use plate and kinematic modelling to reconstruct the two margins in their proper paleogeographic position. This approach highlights that the transition phase is much more complex than previously considered and does not simply form a wide, narrow basin but instead has more variability in its thickness and distribution. Not only does this constrain possible source rock distribution better, it also provides insight into the possible formation of salt basins elsewhere in the Atlantic margin. In addition, we show that the transition phase evolution is intimately linked to the late syn-rift and volcanic stages of margin evolution and that an understanding the lithospheric stretching prior to break-up influences the nature of the transition phase. Not only that, but also early post-rift tectonics play an important role in modifying basin architecture, source-rock distribution and the associated hydrocarbon systems. We conclude that although the transition phase is enigmatic, by considering its evolution within an integrated geodynamic context can we understand not only its spatial distribution and evolution better but also the processes involved as continental lithosphere evolves into the oceanic lithosphere.