Extension Mode and Resulting South Angolan Margin Architectures Controlled by Precambrian Lithospheric Anisotropy

Frederic O. Escosa[1], Michael Denis[2], Jean-Claude R. Ringenbach[2], Michel Guiraud[3]

[1]Terractiva Consulting SL
[2]TotalEnergies S.E.
[3]Université de Bourgogne Franche-Comté

Abstract

We use offshore 2D & 3D seismic reflection and potential field data coupled with field work to investigate the role of lithospheric heterogeneity and shear zone rejuvenation in controlling the along-strike architectural change in the South Angolan margins.

Onshore southern Angola, the pre-rift basement is inherited from several Precambrian deformation events ended by the Pan-African/Brasiliano orogeny accreting four different lithospheric domains with contrasted thickness, fabrics, thermal and chemical composition. From north to south, the continental crust is composed of Neoproterozoic metapelites, Paleoproterozoic gneisses and migmatites and Archean greenstone belts pervasively intruded by TTG granitoids delimited by large Archean – Paleoproterozoic shear zones. Offshore, the interpretation of seismic reflection data reveals different margin architectures segmented by transverse fault zones depicting structural coherence with onshore Precambrian shear zones. We describe in detail several of these offshore transverse structures to determine the geometry of the faults constituting such structures, the age of faulting and how they facilitated segmentation during rifting. This structural analysis together with the observation that some Precambrian shear zones have a similar trend than their equivalent offshore transverse structures, allows us to propose an offshore correlation of the Precambrian basement. The structural inheritance extrapolation is achieved by integrating the structural trends observed onshore with those observed offshore together with the distinction between crust types and associated seismic characters observed on seismic reflection data. The extrapolation suggests that pre-rift rheological heterogeneity led to an enhanced segmentation of the rift system accommodated by the activation of transverse fault zones along pre-existing Precambrian shear-zones. This, in turn, resulted in varying extensional styles, and magmatic budget along the rifted margins. In the north for example, the younger Neoproterozoic lithospheric domain deformed with a ductile behavior and multiple crustal detachments, promoting lithospheric decoupling and a distributed extension, with late continental break-up. To the south, the Archean and Paleoproterozoic lithospheric domain, with stronger strength profile, promoted a more localized extensional deformation and favored an early lithospheric coupling and continental break-up. This ultimately led to the formation of a short margin with increased magmatic budget, where extension was accommodated by high-angle, landward-dipping extensional faults and mantle-exhumation. Moreover, the rejuvenation of Precambrian shear zones also promoted the activation of lithospheric-scale thermal drains, facilitating the emplacement of several magmatic pulses into the upper crust during the margin evolution.

Finally, this work highlights the fundamental importance of incorporating the rheological heterogeneity of the lithosphere when analyzing the formation and evolution of sedimentary basins developed over cratonic provinces. This will lead to a better understanding of the heat flow distribution across the basin and to an improvement of the basin modelling predictions (e.g. generation, migration and accumulation of hydrocarbons and/or de-risking the timing and presence of non-commercial, mantle-related degassing into the targeted reservoirs).