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Mantle densities and rupture criterion: thermo-mechanical modelling applied to the Eastern Gulf of Aden

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The Gulf of Aden is a young oceanic basin, which separates the Arabian from the Somalian plates. The present-day opening velocity is about 2 cm/yr. Continental rifting began at 35 Ma and seafloor spreading at least at 17.6 Ma. The western passive margins, close to the Afar hotspot, are volcanic, while they are non-volcanic in the East. The conjugate margins are relatively close, associated with a very thin sedimentary cover and hence easy to correlate. A large dataset of geological and geophysical information is available. Indeed, three cruises (Encens-Sheba, Encens and Encens Flux, respectively June-July 2000, Feb.-March 2006 and Nov.-Dec. 2006) provided multi-channel and wide-angle seismics, gravity, magnetism, bathymetry, and heat flow data offshore the northeastern Gulf of Aden. More particularly, these data provided us to determine the deep structure of the Oman margin (wide-angle and gravity) and the heat-flow across the margin. Thus, we observed that the ocean-continent transition (OCT) is narrow (15 to 50 km) and shows variations along the margin (volcanism, serpentinisation).

Thermo-mechanical modelling is first realised to determine the influence of the density contrasts between mantle lithosphere-asthenosphere and the mantle lithosphere strength (rupture criterion). The main results show that: (1) the lithosphere-asthenosphere density contrast controls the continental crust flexure and the seafloor depth; and (2) the mantle lithosphere rupture criterion controls the strain localisation, and as a consequence, the margin geometry and the timing of the rifting.

Comparison with our knowledge of the Eastern Gulf of Aden allowed us to constrain the initial geometry, the boundary conditions and the rifting process and evolution that lead to the present day geophysical and geological characteristics observed in this basin. Indeed, we compare results of our modelling with the results of (1) the P-wave velocity modelling, (2) the heat-flow measurements and (3) the topography across the Eastern Gulf of Aden. This model shows that mantle partial melting can occur at the crustal break-up time. The produced melt can dike to the surface and generate oceanic crust. This is in agreement with the observed narrow OCT composed of exhumed continental mantle in the Eastern Gulf of Aden.