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Seafloor spreading initiation in the Red Sea: constraints from geophysical data

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Multibeam, magnetics, gravity and seismic reflection data from the two northernmost oceanic axial segments of the Red Sea, Thetis and Nereus, reveal that the initial accretion of oceanic crust in the central Red Sea occurs in discrete axial deeps.

Thetis Deep is made by coalescence of three sub-basins that become shallower and narrower from south to north. The initial emplacement of oceanic crust, that occurred at South Thetis and Central Nereus roughly $\sim$2.2 and $\sim$2 Ma, respectively, is taking place today in the northern Thetis and southern Nereus tips.

The "intertrough zones" that separate the Thetis axial "oceanic" cell from the Nereus cell to the north, and the Hadarba cell to the south, are devoid of magnetic anomalies and contain thick sediment sequences and relicts of continental crust. The Red Sea central depressed region broadens significantly in the inter-trough zones relative to the "oceanic" segments, indicating that deformation becomes focused in a narrow axial zone as soon as oceanic accretion starts.

Magnetic anomalies suggests a south to north time progression of the initial emplacement of oceanic crust within the Thetis system, with a propagation rate of roughly 30 mm/a, significantly faster than the spreading rate (6.1 mm/a). Magnetic profiles from the northern part of Hadarba Deep (the "oceanic" segment immediately to the south of Thetis), indicate an initial oceanic accretion at $\sim$3 Ma, confirming the south to north progression. Quantitative modelling of magnetic anomalies suggests that, at Thetis and Nereus, the oceanic spreading initiated by a strong pulse of "active" oceanic crust generation and rapid sea floor spreading. This initial burst of crust accretion is observed at the sub-basin scale of Thetis and Nereus deeps.

Our results suggest that each initial discrete axial cell taps a different asthenospheric source and serves as nucleus for axial propagation of oceanic accretion, resulting in linear segments of spreading. Discrete oceanic initial crust accretion is observed also in the southern portion of the Red Sea. In fact, reprocessing of all sea-surface magnetic data from the Red Sea allowed to reconstruct the evolution of the entire divergent margin, showing a northward migration of the initial emplacement of the oceanic crust with an average propagation rate of $\sim$22 mm/a.

Although the impingement from below of the Afar mantle plume may have influenced the evolution of the Red Sea rift, independent along-axis centres of upwelling developed during the rifting stage, due to buoyancy-driven convection within the hot, low viscosity asthenosphere beneath the extending continental lithosphere.