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A combined rigid/deformable plate tectonic model for the evolution of the Indian Ocean

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Plate tectonic reconstructions are essential for placing geological information in its correct spatial context, understanding depositional environments, defining basin dimensions and evolution, and serve as a basis for palaeogeographic mapping and for palaeo-climate modelling. Traditional 'rigid' plate reconstructions often result in misfits (overlaps and underfits) in the geometries of juxtaposed plate margins when restored to their pre-rift positions. This has been attributed to internal deformation pre- and/or syn- continental break-up. Poorly defined continent-ocean boundaries add to these problems. To date, few studies have integrated continental extension within a global model.

Recent plate tectonic reconstructions based on the relative motions of Africa, Madagascar, India and Antarctica during the break-up of eastern Gondwana have not taken into account the effects of deformation; particularly between India and Madagascar, and India and the Seychelles. A deformable plate model is in development that builds on the current rigid plate model to describe the complex multiphase break-up history between Africa, Madagascar, Seychelles and India, the associated magmatic activity and subsequent India/Eurasia collision.

The break-up of eastern Gondwana occurred in the mid Jurassic by rifting between Africa and the India-Madagascar-Australian-Antarctica plates, followed by the Late Jurassic drift of India away from Australia and the Cretaceous break-up of Australia and Antarctica. The northwards drift of the Seychelles-India block in the Tertiary was accommodated by the opening of the Laxmi Basin. This was followed by the eruption of the extensive Deccan flood basalts and the separation of India and the Seychelles. Crustal domains on volcanic margins can be very difficult to define due to the accretion of magmatic material. On these margins, there is much speculation on the position of the continent-ocean boundary and the timing of rifting and sea-floor spreading. The presence of magnetic anomalies indicating variable rates of seafloor spreading and 'jumps' in the axis of seafloor spreading have not as yet been satisfactorily resolved by existing plate models.

Integration of detailed geophysical and geological datasets, combined with published data will be used to produce an enhanced plate tectonic model. This will be coupled with deformable modelling of the extensional margins, incorporating stretching (β) factors and deformation trajectories to calculate the extent of crustal deformation for the main episodes of continental break-up. This will result in more accurate plate tectonic reconstructions for the determination of pre-rift geometries, palaeo-positions of the plates and exploration datasets intersected with them, to aid hydrocarbon exploration in the region.