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Numerical modeling of the Indo-Australian intraplate deformation

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The high level of seismicity observed within the Indo-Australian plate seems to contradict the tenets of plate tectonics : plate rigidity and narrow oceanic plate boundaries. Its deformation pattern and kinematic data inversions suggest that the Indo-Australian plate is a composite plate made of three rigid component plates – India, Capricorn, Australia - separated by wide and diffuse boundaries either extensional or compressional.

To test this model, we used the SHELLS numerical code (Kong & Bird, 1995). The Indo-Australian plate was meshed into 5281 spherical triangular finite elements. SHELLS takes into account the age of the lithosphere and seafloor topography ; assumptions were made on the rheology of the oceanic lithosphere; we also tested the role fracture zones as lithospheric weaknesses. Model boundary conditions are defined only by the plate velocities derived from the rotation vectors between rigid parts of the Indo-Australian plate and their neighboring plates. Different plate velocity models were tested. In a first step, we considered different component plate pairs (India/Capricorn, Capricorn/Australia, India/Australia). Since the limits of their respective diffuse boundary (i.e. the limits of the rigid component plates) are not known, we let the corresponding edge free. In a second step, we considered the whole Indo-Australian plate. Previous meshes were merged to compose the whole Indo-Australian plate. In this case, all velocities on the model boundaries are defined and were set relative to the Capricorn plate.

Our models predict deformation patterns very consistent with that observed. Pre-existing structures of the lithosphere play an important role in the intraplate deformation and its distribution. The Chagos Bank focuses the extensional deformation between the Indian and Capricorn plates. The reactivation of fossil fracture zones may accommodate large part of the deformation both in extensional areas, off the Central and Southeast Indian ridges, or in compressional areas, in the Central Indian and Wharton basins. Reactivation of the Eocene FZ's in these basins may explain the drastic change in the deformation style on either side of the Ninetyeast ridge. The rates of extension or shortening, inferred from the predicted strain rates, are consistent with previous estimates based on different approaches.