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Deformation of Indian Ocean Lithosphere Implies Highly Non-linear Rheological Law for Oceanic Lithosphere

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The width of diffuse oceanic plate boundaries is determined by the rheology of oceanic lithosphere. Here we apply thin viscous sheet models, which have been successfully applied to deformation in several continental deforming zones, to investigate the deformation of oceanic lithosphere in the diffuse oceanic plate boundaries between the India, Capricorn, and Australia plates. We apply kinematic boundary conditions based on the current motion between these plates. We neglect buoyancy forces due to plate thinning or thickening and assume that the thin viscous sheet has the same depth-integrated non-linear viscosity coefficient everywhere. Our initial models have only one adjustable parameter, n, the power-law exponent, with n=1, 3, 10, 30, 100. The predicted width of the deforming zone decreases with increasing n, with n $\geq$ 30 explaining the observations. This n-value is higher than has been estimated for continental lithosphere, and suggests that more of the strength of oceanic lithosphere lies in layers deforming by faulting or by dislocation glide than for continental lithosphere. To obtain a stress field that better fits the distribution and type of earthquake focal mechanisms in the diffuse oceanic plate boundary, we add a second adjustable parameter, representing the effect of slab-pull stretching the oceanic plate near the Sumatra trench. We show that an average velocity increment on this boundary segment of 5 mm/a (relative to the average velocity of the India and Australia plates) fits the observed distribution of fault types better than velocities of 3.3 mm/a or 10 mm/a.