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Sediment control on subduction plate speeds: insights from 2D dynamic models

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Tectonic plate velocities predominantly result from a balance between the potential energy change of the subducting slab and viscous dissipation in the mantle, bending lithosphere, and slab–upper plate interface. A range of observations suggest that slabs may be weak, implying a more prominent role for plate interface dissipation than previously thought. The shallow thrust interface is commonly assumed to be weak due to an abundance of fluids and near-lithostatic pore fluid pressures, but little attention has been paid to the influence of the deeper, viscous interface. Here we show using both semi-empirical calculations as well as fully 2D dynamic models (using the convection code ASPECT) that the deep interface viscosity in subduction zones is strongly affected by the relative proportions of sedimentary to mafic rocks that are subducted to depth. Where sediments on the down-going plate are sparse, the deep interface is dominated by mafic lithologies that metamorphose to eclogites, which exhibit viscosities 1–2 orders of magnitude higher than the asthenospheric mantle, and reduce subduction plate speeds. In contrast, where sediments are abundant and subducted to depth, the deep interface viscosity is 1–2 orders of magnitude lower than the asthenospheric mantle, thus allowing significantly faster plate velocities. This correlation between subduction plate speed and deep sediment subduction may help explain dramatic accelerations (or decelerations) in convergence rates, such as the acceleration documented for India–Asia convergence during the mid-Cenozoic.