Gravitational collapse of an overriding plate in subduction zones: an insight from lubrication theory.

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In a convergent tectonic setting the overriding plate (OP) accommodates considerable lithospheric shortening to build characteristic elevated topography. This study accounts for the role of dynamic pressure (P) produced in the subduction wedge to explain how the convergent motion support the excess gravity load of the OP arising from elevated topography mass. Based on lubrication theory we present an analytical solution to evaluate the magnitude of P in the wedge as a function of subduction velocity (u), convergence angle (α) and viscosity (μ) of wedge materials, which eventually determines the load bearing capacity of the wedge in the OP. For given α and μ values, the convergence can support the excess gravity load of OP only when u exceeds a threshold value (u*) (stable state). Otherwise, the OP undergoes gravitational collapse as u < u* (unstable state). Using the same analytical solution we derive an inverse relation of u* with wedge viscosity. We performed computational fluid dynamic (CFD) simulations as well as analogue experiments within the framework of lubrication theory to investigate the crustal flow patterns in the stable and the unstable states of OP. The model results suggest that the OP stability can dramatically change the modes of crustal flow pattern and topography building. Finally, we discuss the implications of our lubrication model to explain the time dependent transitions in the Tibetan plateau tectonics as a function of convergence velocity (u) recorded in the history of India-Asia collision.