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Subducting slab damage at the outer rise explains the subduction dichotomy of strong plates and weak slabs

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Experimentally calibrated rheological laws predict high effective viscosity (>1024 Pa s) of subducted slabs in the upper mantle implying slab/mantle viscosity contrast of »1000. In contrast, a number of observations combined with numerical modeling studies suggest that this contrast is much lower (on the order of 10-100) and strong dichotomy exists between the properties of the strong lithospheric plates at the surface and much weaker subducted slabs (Petersen et al., 2016). We address this apparent paradox by investigating and modeling in 2D various damage processes systematically affecting subducting plates in the outer rise bending region. We demonstrate that the brittle top region of subducting plates is pervasively damaged by normal faulting and associated downward water suction and serpentinization (Faccenda et al., 2009) whereas ductile bottom portion of the plate is subjected to pervasive grain size reduction assisted by Zenner pinning (Bercovici and Ricard, 2014). As the result, subducting strength and effective viscosity of subducted slabs drop by many orders of magnitudes compared to that of the undamaged plates at the surface. We demonstrate that slab segmentation may occur at depths due to the feedback between brittle and ductile damage localization. We discuss possible implications of our slab damage theory for modern subduction and plate tectonic

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