Two-dimensional numerical experiments on subduction initiation in oceanic lithosphere: Effects of rheological properties of hydrous minerals

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How subduction begins on the Earth remains one of major outstanding problems in plate tectonics. For plate subduction to be initiated, previous numerical studies have assumed a preexisting weak fault with the coefficient of friction (μ) of around zero. When comparing the surface environment of the Earth with other terrestrial planets where plate tectonics is not occurring, only earth has an ocean. If seawater transport deeply along faults between plates, water–rock interaction will occur to form mechanically weak hydrous minerals. Therefore, we focus on effects of rheological properties of hydrous minerals and conduct a two-dimensional numerical simulation of subduction initiation in oceanic lithosphere. We found that plate subduction occurs with an assumption of antigorite flow law (dislocation creep), talc friction (i.e., μ= 0.1), and high pore fluid pressure ratio (λ = 0.9) for the weak fault zone. We also confirm that the maximum average strength of the weak fault for subduction to be initiated must be below 5 MPa. In our models, no oceanic plates sinks deep into the mantle, suggesting that additional effects are needed for the plate to fracture and then subduct into the deep mantle.

Keywords: plate tectonics, subduction initiation, hydrous mineral, oceanic lithosphere, antigorite, talc

