Effects of the tensional strength of the lithosphere on subduction

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We have conducted a numerical simulation of behaviours of plate boundaries, where deformation concentrates locally, in an attempt to accounting for more realistic features. In our previous models, the plate boundary is treated as a thicker low-strength layer due to the hysterisis dependence on the past fracture zone using low-resolution numerical modelling. However, it was not realistic because the oceanic crust with substantial water content should be treated as a weak layer. We investigate a process to initiate and develop subduction with a low-strength layer that acts as the plate boundary and has the same thickness as that of the oceanic crust. Another problem in our previous modelling is that the shape of the subducted slab is controlled according to the angle of the weak plate boundary imposed initially. To overcome this, and let the slab subduct freely, we have considered the difference of tensional and compressional strength as a rheology of lithosphere in the model.

We first improve our simulation code to perform computations on a variable grid to resolve the finer structure of a thin plate boundary in the modelling. The region of a finest grid is divided into 2 km meshes. The layer with the hysterisis of the yield strength is set to be 6 km. We assume the tensional strength of the lithosphere to be one-third of the compressional strength in the rheology model. The initial temperature of the oceanic plate is set in a half-space cooling model with the age of 50 or 100 Myr.

Even if we set the plate boundary layer to the same thickness as the oceanic crust, our results show that two plates can decouple because of the concentration of strain. The oceanic plate can subduct into deep mantle if the strength of the plate boundary is low. In the cases including the tensional and compressional strength, the plate subducts more easily than those with only the compressional strength. The fracture in the weaker zone of tensional strength is an effective mechanism to generate subduction. In the case, with a thicker overriding plate, the tensional strength does not influence the style of the subducted slabs. On the other hand, when we employ a thinner overriding plate, the trench moves ocean-ward because of gravitational instability of the slab and that results in shallower dip angle.