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The initiation of subduction at the passive margin

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The subduction at the passive margin begins because of the gravitational instability. It is theoretically difficult due to the stiffness of plate. We quantitatively try to examine rheological conditions of lithosphere to initiate subdution. We use rheological parameter for the strength model of lithosphere obtained by the recent laboratory experiments. No external forces are applied in the model. In the case of the weak continental crust, fracture of oceanic lithosphere is generated by the thrusting of crust induced by the extension of it. The subduction, however, cessate from proceeding. In the case of stronger crust, even fracture doesn't occur. This would imply that the other tectonic mechanism or weaker strength of the lithosphere are necessary for the initiation of the subduction.

We have not yet clearly understood the mechanism for the plate to initiate subduction at the passive margin formed by the division and movement of continents.

The model most commonly accepted is "passive margin failure"(Turcotte et al, 1977). In this model, the subduction begins at the passive margin because of the gravitational instability of the old oceanic lithosphere contacted with a less dense continental crust. Theoretical studies, however, showed that it is very difficult for the plate to subduct because of the stiffness(Cloetingh et al., 1989; Ogawa, 1990; Mueller & Phillips, 1991).

We quantitatively try to examine rheological conditions of the lithosphere to initiate subduction at the passive continental margin by using fully dynamic numerical models in a 2-D box. The process of the subduction initiation are simulated in a self-consistent manner, namely no external forces are applied in our models. We use a Boussinesq fluid with no internal heating for mantle convection. We consider tectonic settings in which a compressive force generated by the ridge push force in the oceanic lithospere whose thickness increases with the age. We use rheological parameter for the strength model of the lithospere, obtained by the recent laboratory experiments, known as a three-layer model. In this model, the oceanic lithosphere has brittle failure(frctional sliding), plastic failure, and viscous flow(diffusional creep) zone from continental surface, and has a wider plastic failure zone and a smaller strength of lisosphere than a two-layer model that it is conceived before. The maximum yield stress and frictional coefficients is changed from the model to the model. We also introduce both the effects of the buoyancy of continental crust and the rheological difference from that of oceanic lithosphere. It is because of the inhomogeneous distribution of volatile and the compositional difference between continental and oceanic lithosphere. We use rheology depending on the past history of yielding for the recipe of the plate boundary. A low viscosity zone simulating a fault zone is formed by the stress concentration at the segment with lower yield stress reduced by the past yielding.

In the case of the weak continental crust, fracture of oceanic lithosphere, which is precursive process of the onset of the subduction, is generated by the thrusting of continental crust induced by the extension of it. The subduction, however, cessate from proceeding and the subducted slab cannot be developed. In the case of stronger continental crust, even fracture does not occur. This would imply that the other tectonic mechanism or weaker strength of the lithosphere are neccessary for the initiation of the subdution.