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Plate Subduction Accompanied by Back-Arc Spreading: The Effect of Slab Rollback

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Back-arc spreading is an interesting phenomenon, for it occurs in plate subduction zones where two plates converge. Presently active back-arc basins are the Mariana Trough, the Lau Basin, the East Scotia sea and so on. The common features of back-arc basins are tensile stress fields in the back-arc regions, local increase of slip rate (slip-rate excess) at the plate interfaces, and swell of the plate boundaries.

In the JpGU meeting 2006, we proposed nonlinear, coupled model of plate subduction and back-arc spreading and showed that this model would a possible scenario for the evolution of back-arc basins. However, the model cannot produce enough values of back-arc spreading rates, slip-rate excess and swell of the plate boundary for explanation of the actual back-arc basins. Furthermore, increase of slip rate is expected to produce larger amplitude of free air gravity anomalies in the arc-trench system while actual arcs such as the Mariana arc do not.

The most plausible reason for the discrepancy between our model and actual subduction zones with back-arc spreading may be the neglect of the effect of slab rollback, spontaneous descending of cold slab due to negative buoyancy. In this presentation, we quantitatively estimate the effects of slab rollback in the process of steady plate subduction using 2-D model.

Mechanical interaction at plate interfaces is rationally expressed by the increase of tangential displacement discontinuity (dislocation) at plate interfaces. Theoretically, the spatial change in magnitude and direction of the dislocation vector causes crustal deformation in the surrounding area.

It has already been shown that usual steady plate subduction produces positive-negative anomaly pattern in the arc-trench system and tensile stress fields in the back-arc region. In this case, uniform slip along curved plate interfaces acts as the source of crustal deformation. Thus, curvature of the plate interface has an important effect on the back-arc region.

In the model incorporating the effect of slab rollback, we give the distribution of slip rate depending on the curvature. This corresponds to expressing the plate bended by negative buoyancy of the slab with no plate-to-plate interaction. The deformation fields due to such distribution of slip rate weaken the deformation fields due to the curvature of plate interfaces.