Back-arc spreading and slab-mantle interaction

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To understand the dynamics of back-arc spreading and slab-mantle interaction, I performed 2D numerical simulations. The model has 2900 km depth and 8000 km width and is composed of continental crust, oceanic crust, upper mantle, mantle transition zone and lower mantle. Each rock types have a visco-plastic rheology prescribed by the temperature and pressure dependent linear viscosity, the dislocation glide (approximated by a power law with a high stress exponent) and the effective frictional coefficient. Simulations were performed under combinations of the age of subducting plate (60 and 100 Ma) and the velocity of overriding plate (0, 1and 2 cm/yr).

For a case of an old subducting plate and a stationary overriding plate, the model shows periodic back-arc spreading. The trench retreat caused by the back-arc spreading results in the development of stagnant slab on the bottom of the mantle transition zone. For cases of a young subducting plate and/or a moving overriding plate toward trench, the model shows no back-arc spreading and the slab penetrates to the lower mantle. The geometry of slab in the lower mantle changes with the velocity of overriding plate. For cases of a stationary overriding plate and a young subducting plate, the slab sinks vertically toward the bottom of lower mantle. For cases of an overriding plate velocity of 2 cm/yr, irrespective of the age of subducting plate, the slab sinks slowly keeping nearly horizontal geometry.

These relations between the plate motion including back-arc spreading and the slab geometry are, at least qualitatively, concordant with geophysical observations. The back-arc spreading along the margins of NW Pacific are caused by subduction of old oceanic plate and are accompanied by stagnant slab. The slabs beneath Middle and South America, where young oceanic plates subduct, penetrate to the lower mantle. These results indicate that back-arc spreading and the slab geometry are mostly controlled by the age dependent rigidity of slab and the motion of overriding plate.

Keywords: back-arc spreading, slab-mantle interaction, stagnant slab

