3-D Modelling of Spontaneous Subduction Initiation at Passive Margins

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The initiation of subduction is a poorly understood process, though subduction is the key process for plate tectonics on Earth. Oceanic lithosphere becomes denser than the underlying asthenosphere within 10 - 50 Ma after it forms at a mid-ocean ridge due to the cooling from the surface. However, despite the favorable gravitational instability and ridge-push, the bending and shear resistance of the lithosphere prevent subduction from arising spontaneously. Subduction initiation at passive margins has been recently investigated numerically in 2D (Nikolaeva et al., 2010), with (i) positive buoyancy and (ii) thinning (e.g. rifting) of the continental lithosphere been the main factors controlling this process. Nevertheless three-dimensional (3D) geometry and dynamics of this process as well as influences from curvature of a passive margin remain enigmatic.

We carried out 3D numerical experiments using the code I3ELVIS to model the spontaneous onset of retreating subduction at a passive margin. We varied model parameters as the thickness of the continental lithosphere, the curvature of the passive margin and the rheological properties of the mantle and the crust.

Similarly to 2D cases (Nikolaeva et al., 2010) three main regimes of passive margin evolution are identified: stable margin, overthrusting and proper subduction. Our models demonstrate that subduction initiation is strongly affected by fluid release from the oceanic lithosphere that begins to subduct. This process is associated with an intense development of partially molten hydrated thermal chemical plumes under the extending continental plate which should result in the strong magmatic pulse related to the beginning of subduction. Our results also suggest that 3D effects arising from margin curvature can be very important for slab geometry and dynamics of subduction initiation.

References

Nikolaeva, K., T.V. Gerya, and F.O. Marques (2010), Subduction initiation at passive margins: numerical modeling, J. Geophys. Res., doi:10.1029/2009JB006549.