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The influence of metastable pyroxene on the dynamics of subduction

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Tomographic images show that some slabs penetrate straight into the lower mantle, whereas others seem flatten and stagnate in the mantle transition zone. The dynamics of cold subducting slabs are mainly controlled by negative thermal buoyancy forces and by buoyancy anomalies due to density contrasts of the different mineralogical phases. Recent experiments show that pyroxene transforms to its high-pressure phase (garnet-majorite) at very slow rates, and pyroxene can remain metastable to temperatures as high as 1400 °C (van Mierlo et al., 2013).

Because metastable pyroxene may potentially persist in subduction zones over large volumes and to great depths, a self-consistent subduction model has been used to investigate the influence of metastable phase on the dynamics of subducting oceanic lithosphere. The phase boundary of pyroxene to garnet (250 km equilibrium depth) is considered together with the phase transition of olivine to spinel (410 km equilibrium), and spinel to perovskite-magnesiowustite (670 km equilibrium). The kinetics of the phase transition in pyroxene-garnet is treated considering a temperature-dependent diffusion rate. To quantify the buoyant contributions of the metastable phase on the subduction dynamics, an extensive parameter sensitivity study has been performed.

Preliminary results from this study illustrate that the buoyancy effect of metastable phase is significant. Slab age and phase change kinetics are the most dominant parameters, and buoyancy effects are stronger for old subducting lithosphere and for low diffusion rates, favoring the slab stagnation in the transition zone.