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Slab Stagnation and Buckling in the Mantle Transition Zone: Rheology, Phase Transition, Trench Migration, and Seismic Structure

Craig R. BINA[1#+], Hana ČÍŽKOVÁ[2]

[1]*Northwestern University, United States*, [2]*Charles University in Prague, Czech Republic*

[#]*Corresponding author: craig@earth.northwestern.edu* [+]*Presenter*

Subducting slabs exhibit buckling instabilities and folding behavior in the mantle transition zone for various combinations of dynamical parameters, accompanied by temporal variations in dip angle, plate velocity, and trench retreat. Governing parameters include both viscous forces (slab and mantle rheology) and buoyancy forces (slab thermal structure and mineral phase relations). In 2D numerical experiments, many parameter sets yield slab deflection at the base of the transition zone, with quasi-periodic oscillations in anticorrelated plate and rollback velocities, producing undulating stagnant slabs as buckle folds accumulate subhorizontally atop the lower mantle. Interactions with mantle phase transitions are important components of this process (Bina and Kawakatsu, *PEPI,* 2010; Čížková and Bina, *EPSL,* 2013).

For terrestrial parameter sets, trench retreat is nearly ubiquitous and trench advance quite rare, due to both rheological and ridge-push effects (Čížková and Bina, *EPSL,* 2013). Recent global plate motion analyses suggest trench advance is also rare on Earth, largely restricted to the Izu-Bonin arc (Matthews et al., *AGU,* T43D-2682, 2013). We explore the conditions necessary for terrestrial trench advance through dynamical models involving the unusual geometry bounding the Philippine Sea.

Details of buckled stagnant slabs are difficult to resolve due to smoothing in seismic tomography, but velocity structures for compositionally layered slabs, spatially low-pass filtered for comparison with tomographic P-wave velocity anomalies, fit observations beneath northeast China better for a stagnant slab which undulates due to compound buckling than for a flat-lying slab (Zhang et al., *GGG,* 2013). Earthquake hypocentral distributions and focal mechanisms provide further insights into slab buckling, appearing to vary systematically across regions of slab stagnation (Fukao and Obayashi, *AGU,* DI14A-01, 2013). Stress field evolution, computed from our dynamical models, should help to illuminate such observations.