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Opening and closing slab windows in congested subduction zones

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Subduction zones often try to swallow buoyant material which is embedded in the oceanic lithosphere: plume material or hotspot residues, oceanic plateaux, and fragments of continental material. This often results in the formation of a slab window and it has been shown (Mason et al, 2010; Betts et al, 2012) that this window strongly influences the subsequent evolution of the slab and the advance/retreat rate of the trench.

The buoyant material typically pushes the trench into a local state of advance, and the creation of the slab window allows the rest of the trench to retreat as the mantle behind the slab flows in through the window. This situation is inherently unstable: if the buoyancy anomaly is finite in size, then the retreating trench will soon move behind the anomaly and juxtapose negatively buoyant oceanic lithosphere with active subduction. This creates the potential to close the slab window and, in doing so, transfer the buoyant material to the over-riding plate.

Models show that this closure of the window initially occurs through a lateral rollback process followed by a catastrophic re-initiation of subduction behind the colliding buoyant anomaly. This rollback leaves a characteristic, tightly rolled remnant in the mantle and significant rotation in the over-riding plate and the newly-docked block. The over-riding plate is thrown into extension perpendicular to the original orientation of the trench.

This same situation applies at the late-stages of a closing ocean due to the passive margin geometry and the presence of debris collected from the closing ocean floor and it seems likely that these models can also be applied to the complicated geometry of subduction in such environments.

Mason, W. G.; Moresi, L.; Betts, P. G. & Miller, M. S. Three-dimensional numerical models of the influence of a buoyant oceanic plateau on subduction zones Tectonophysics, 2010, 483, 71-79
P. Betts, W. Mason, L. Moresi, The influence of mantle plumes on subduction zone dynamics, Geology, 40, 739-742 (2012)