



## Mid-mantle slab break-off as a mechanism for slab remnants in the lower mantle

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Fragmented and broken slivers of slab material in the lower mantle have been consistently imaged for older subduction systems such as the Tonga and the Farallon systems VanderHilst1995, Schellart2012, Fukao2013, Sigloch2008, Sigloch2011, Goes2017, VanderMeer2017. These slab remnants, identified as fast anomalies in seismic tomography, lie directly beneath patches of slow mantle material. The latter is sandwiched between the lower-mantle anomalies and the upper-mantle slab continuously connected to the surface at the trench Sigloch2008, Sigloch2011, Goes2017. This implies a clear break of the slab remnant from the 'parent' slab above it, resulting in either a slab window or even a full slab gap.

Previous studies have suggested a variety of processes to explain and justify the presence of slab remnants in the lower mantle. However, most if not all of these involve surface processes that require complicated kinematics and drastic plate reorganisations Sigloch2008, Sigloch2011, Schellart2012. Here, we propose that many remnant slabs in the lower mantle are the result of mid-mantle slab break-off, rather than slab fragmentation at the trench. We suggest that this mechanical decoupling is due to stresses undergone by the slab as it interacts with both a low viscosity layer that encourages penetration and a phase change that encourages stagnation simultaneously. This mechanism can explain both the presence of remnant slabs and their often unorthodox orientations and locations with respect to the parent slab and the current subduction regime, without invoking complicated kinematics at the surface.

We present a suite of 2-D self-consistent, single-sided subduction models to support our hypothesis. Our models combine a phase change at 660 km with a low viscosity layer between 660 km and 1000 km Rudolph2015. We use the finite difference/volume multigrid code StagYY Tackley2008 to solve our models and apply the 'sticky air' approach to generate realistic topography at the trench, and on the subducting and overriding plates. Hence, we are also able to measure and quantify the surface response to the subduction dynamics, including the mid-mantle slab break-off.

This approach will not only shed light on mid-mantle subduction dynamics but it also has the potential to refine our understanding of old and complex subduction systems on Earth.