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Mantle flow and dynamic topography associated with slab window opening

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A slab window is defined as an “hole” in the subducting lithosphere. In the classical view, slab windows develop where a spreading ridge intersects a subduction zone. The main consequences of this phenomenon are the modifications of the physical, chemical and thermal conditions in the backarc mantle that in turn affect the tectonic and magmatic evolution of the overriding plate. In this work, we perform dynamically self-consistent mantle-scale laboratory models, to evaluate how the opening of a window in the subducting panel influences the geometry and the kinematics of the slab, the mantle circulation pattern and, finally, the overriding plate dynamic topography. The adopted setup consists in a two-layer linearly viscous system simulating the roll-back of a fixed subducting plate (simulated using silicone putty) into the upper mantle (simulated using glucose syrup). Our experimental setting is also characterized by a constant-width rectangular window located at the center of a laterally confined slab, modeling the case of the interaction of a trench-parallel spreading ridge with a wide subduction zone.

We find that the geometry and the kinematics of the slab are only minorly affected by the opening of a slab window. On the contrary, slab induced mantle circulation, quantified using Feature Tracking image analysis technique, is strongly modified and produces a peculiar non-isostatic topographic signal on the overriding plate. Assuming that our modeling results can be representative of the natural behavior of subduction zones, we compare them to the Patagonian subduction zone finding that anomalous backarc volcanism that developed since middle Miocene could result from the lateral flowage of subslab mantle, and that part of the Patagonian uplift could be dynamically supported.