Mapping the flow during retreating subduction: laboratory models analyzed by Feature Tracking

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Three-dimensional dynamically consistent laboratory models are realized to model the large-scale mantle circulation induced by subduction of a lateral migrating slab. A laboratory analogue of a three layer linearly viscous slab-upper mantlelower mantle system is established in a silicone putty, glucose syrup, tank experiment. The circulation pattern is continuously monitored and quantitatively estimated using a Feature Tracking (FT) image analysis technique. The effects of plate width and mantle viscosity/density on mantle circulation are systematically considered. The evolution of the experiments shows that rollback subduction generates a complex 3-D time-dependent mantle circulation pattern characterized by the presence of two distinct components: the poloidal and the toroidal one. Spatial and temporal features of mantle circulation are carefully analyzed. Implications of these models include that (1) poloidal and toroidal mantle circulation are both active since the beginning of the subduction process. The poloidal component is the answer to the viscous coupling between the slab motion and the mantle. The toroidal component is produced by the lateral slab migration. (2) Mantle circulation is episodic. (3) Plate width influences mantle circulation. (4) The description of mantle flow in subduction zones cannot be correctly approached by models assuming a 2-D steady state process.