Effect of along-trench slab dimension on subduction-induced upper mantle flow: Insights from 3-D laboratory models

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Three-dimensional self-evolving subduction models with various along-trench dimensions have been quantitatively analysed in the laboratory by means of a stereoscopic Particle Image Velocimetry (sPIV) technique. The purpose was (1) to provide information on the pattern of the upper mantle flow induced by subduction, particularly focusing on the location and magnitude of upwellings around the lateral slab edges and in the mantle wedge, (2) to study the evolution of mantle upwellings in terms of location and magnitude, and (3) to study the effect of along-trench slab dimension on upwelling location and magnitude. The model results show that 4 types of upwelling are generated by subduction in a Newtonian upper mantle. One of these upwellings occurs laterally away from the sub-slab domain and could potentially trigger decompression melting, thereby explaining the occurrence of a certain type of intraplate volcanism. Two other significant upwellings are observed in the mantle wedge. The tested along-trench slab dimensions were comparable to slabs of narrow (e.g., Calabria) to wider (e.g., Tonga-Kermadec-Hikurangi) subduction zones. The results indicate that both the location and magnitude of the upwelling occurring laterally away from the sub-slab domain are affected by the along-trench slab dimension, with wider slabs producing faster and more focused upwellings that are located closer to the lateral slab edges. The models also seem to show that the along-trench slab dimension controls the intensity of upwellings in the mantle wedge.

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