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Control of Hikurangi plateau-Chatham rise and free northern slab edge on evolution of the Tonga-Kermadec-Hikurangi subduction zone

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The Tonga-Kermadec-Hikurangi subduction zone presents an atypical dynamics when compared to most subduction systems. An uncommon feature is the marked along-trench variation in trench retreat and subduction velocities, which increase gradually from south to north to reach the fastest velocities on Earth close to the northern slab edge. Another intriguing feature is the existence of a broad trail of volcanoes, including the Samoa islands, north of the northern lateral slab edge. The volcanoes do not share all the characteristics of typical plume-induced volcanic islands and their origin is thus questioned. Here we present results of fully dynamic three dimensional analogue subduction models in which we included the effect of the Hikurangi plateau-Chatham rise and free northern slab edge on evolution of the Tonga-Kermadec-Hikurangi subduction zone. We tested how the kinematic asymmetry can be produced by different boundary conditions between the southern and northern lateral slab edge. Notably, presence of the Chatham rise and the Hikurangi plateau born by the subducting plate to the south of the subduction zone induces a strong density anomaly locally, whereas there is a free lateral slab edge to the north. We also quantified the upwelling component of upper mantle flow associated to quasi toroidal circulation around the northern slab edge and we compared the location of its maximum magnitude with the location of volcanics in the natural prototype. Our model results show that presence of the Hikurangi plateau and Chatham rise control the kinematic evolution of the subduction models, inducing a trench-parallel increase in trench retreat and subduction velocity from south to north. Furthermore, maps of the subduction-induced mantle flow show that a broad and fast upwelling is produced around the northern free slab edge. Its location at different time steps could explain the occurrence of volcanism that is not well explain by a plume origin. We thus propose that volcanism at the northern slab edge of the Tonga-Kermadec-Hikurangi subduction zone is induced by subduction, where mantle decompression melting and interaction between the melt and slab produce an adakite signature that is observed in the presently studied and also other natural subduction zones.

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