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

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1 Introduction

The Tonga-Kermadec-Hikurangi subduction zone presents a marked along-trench variation in trench retreat and subduction velocities, which increases gradually from south to north to reach very fast velocity close to the northern slab edge. The origin of this kinematic asymmetry can be sought as produced by lateral variation in subducting plate density, and by different boundary conditions between the southern and the northern lateral slab edges. Presence of the Chatham rise and Hikurangi plateau (born by the lateral subduction of the Pacific plate and, thus, by the combined effect of lateral density variations and boundary conditions) is required to induce a strong positive density anomaly locally, whereas there is a free lateral slab edge to the north. We studied the effect of the presence/absence of the Chatham rise and Hikurangi plateau and their thickness on evolution of the Tonga-Kermadec-Hikurangi subduction zone using fully dynamic laboratory models. We particularly focused on the resulting subducting plate kinematics and on the induced mantle flow for the northern half of the subduction zone.

Intraplate volcanism occurring along the Samoan trail cannot be entirely attributed to a hotspot model. The fully-dynamic analogue models aim to test if subduction-induced mantle upwelling at the northern lateral slab edge can be an alternative mechanism to explain the intraplate volcanism.

2 Method

The 3 components of the mantle flow velocity field are computed from the in-plane components of each camera. Particle tracking and cross-correlation technique to compute local velocity vector for each camera (from Raffel et al., 2007)

3 Results

A line drawing of the 3 components of the mantle flow velocity field in a vertical plane (Schellart and Strak, 2016)

4 Implications for origin of mantle melting

3D geodynamic scenarios that are possibly at the origin of mantle decompression melting that produces the Samoan volcanism

5 Conclusions

Our model results show that presence of the Hikurangi plateau and Chatham rise strongly affect the evolution of the subduction models. Without these geological features subduction occurs symmetrically with a trench curvature evolving from quasi-linear to slightly convex towards the overriding plate in the centre of the subduction zone, which is characteristic of subduction zones with intermediate trench-parallel slab extent. Additionally, the trench retreat pattern is symmetric in time and space along the trench, and the subduction-induced mantle upwelling is focused around the northern free slab edge. Moreover, maps of the subduction-induced mantle flow show that a mantle upwelling is produced around the northern free slab edge which is focused close to the northern slab edge. It is long-lived and quite broad (ca. 3600 km). This upwelling always stays focused close to the northern slab edge during progressive slab rollback and is long-lived and quite broad (ca. 3000 km in the trench-perpendicular direction).

The subduction-induced mantle upwelling could in part explain the Samoan volcanism if end-member values are considered for the ambient mantle temperature and for the lithospheric thickness. A more plausible process to trigger mantle decompression melting may be through interaction between the subduction-induced upwelling and the Samoan mantle plume head. In that case the plume head brings a temperature anomaly and the subduction-induced mantle upwelling triggers decompression.