Stagnant slab tectonics of the Japan and northern Tonga slabs

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Seismic tomography has revealed enigmatic stagnant slab anomalies under Japan, Korea and NE China (i.e. the Japan slab). The stagnant slabs flatten near the mantle transition zone around ~410 to 660 km depths and extend >2000 km westward from the NW Pacific subduction zones. The location of the outboard stagnant slabs far inland under Eurasia cannot be explained by slab rollback alone and pose a challenge to our current understanding of subducted slab dynamics, in which slabs sink vertically over time with minimal lateral motion.

In this study, we use new and recently published 3D slab mapping, slab unfolding and plate reconstruction constraints (Wu et al., 2016, JGR) from MITP08 and GAP_P4 global tomography (Li et al., 2008, G3; Fukao et al., 2013, JGR). We show that the Japan stagnant slabs are best reconstructed as Pacific slabs that subducted in the Cenozoic after Pacific-Izanagi ridge subduction between 60 to 50 Ma. Mantle flow forward models reproduce our Japan slab reconstruction results (Seton et al., 2015, GRL). Our reconstruction implies the Japan slabs moved laterally westwards within the upper mantle and transition zone after subduction at near-plate tectonic rates (~2 cm/yr over 50 Ma), indicating a greater lateral mobility of slabs within the upper mantle and transition zone than previously recognized.

Using our Japan slab subduction model, we re-examine the enigmatic Vityaz deep earthquakes under the Fiji Basin, which are widely thought to be a globally-unique case of seismicity within a foundered and detached slab. Our Tonga slab mapping shows the Vityaz earthquakes are actually part of a >2500 km-long mega-Wadati-Benioff zone of the northern Tonga stagnant slab. Our slab reconstruction suggests the northern Tonga slab moved laterally westward in a similar fashion to the Japan slabs, but at a faster rate of >5 cm/yr over 15 Ma within the upper ~660 km. Our results suggest that earthquakes can be produced thousands of kilometers away from a subduction zone from lateral movements of still-attached but mobile stagnant slabs within the uppermost ~660 km mantle.

Keywords: Stagnant slabs, seismic tomography, Japan slab, Tonga slab, Izanagi plate

