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The Hikurangi Plateau: Tectonic Ricochet and Accretion

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80 million years between interactions with different subduction systems provided time for the Hikurangi Plateau and Pacific Ocean lithosphere to cool, densify and strengthen. Neogene subduction of the Hikurangi Plateau occurring orthogonal to its Cretaceous predecessor, provides a unique opportunity to explore how changes to the physical properties of oceanic lithosphere affect subduction dynamics. We used Underworld to build mechanically consistent collision models to understand the dynamics of the two Hikurangi collisions.

The Hikurangi Plateau is a ∼112 Ma, 15km thick oceanic plateau that has been entrained by subduction zones immediately preceding the final break-up of Eastern Gondwana and currently within the active Hikurangi Margin. We explore why attempted subduction of the plateau has resulted in vastly different dynamics on two separate occasions. Slab break-off occured during the collision with Gondwana, currently there is apparent subduction of the plateau underneath New Zealand.

At ∼100Ma the young, hot Hikurangi Plateau, positively buoyant with respect to the underlying mantle, impacted a Gondwana Margin under rapid extension after the subduction of an mid-ocean ridge 10-15Ma earlier. Modelling of plateaus within young oceanic crust indicates that subduction of the thickened crust was unlikely to occur. Frontal accretion of the plateau and accompanying slab break-off is expected to have occured rapidly after its arrival. The weak, young slab was susceptible to lateral propagation of the ∼1500 km window opened by the collision, and break-off would have progressed along the subduction zone inhibiting the "step-back" of the trench seen in older plates. Slab break-off coincided with a world-wide reorganisation of plate velocites, and orogenic collapse along the Gondwana margin characterised by rapid extension and thinning of the over-riding continental plate from ∼60 to 30km.

Following extension, Zealandia migrated to the NW until the Miocene allowing the oceanic crust time to densify and strengthen. At ∼23Ma, the inception of the Hikurangi Subduction Zone drove the scissor rotation of the Australian and Pacific Plates creating displacement along the Alpine Fault. The Hikurangi Plateau was once again drawn into the subduction system, this time with subduction occurring orthogonal to the Cretaceous suture.

The northern margin of the plateau has begun to subduct, but towards the southern terminus, the trench appears to be pinned. The result of the locked subduction zone is the asymmetric roll-back of the Hikurangi-Kermadec-Tonga subduction system around the point where the trench transitions from roll-back to shortening. The oceanic Pacific lithosphere is now signficantly negatively buoyant while the thickened lithosphere of the plateau maintains a slight positive buoyancy. The oceanic crust provides sufficient slab pull to drive subduction of the northern plateau, aided by the thin ∼500km width of the plateaus subducting front. The increased strength profile of the older subducting lithosphere allows buoyancy forces to be transmitted to the over-riding plate, allowing continued convergence and hindering slab-breakoff.