Plate bending and drops in P-wave speeds for the crust and upper mantle of the Hikurangi Oceanic Plateau as it subducts beneath southeastern North Island, New Zealand

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As the Hikurangi oceanic plateau subducts beneath eastern North Island, New Zealand, there is a profound drop in seismic P-wave speeds for the crust and top 30 km of the upper mantle. An approximate 10% drop in V_p in the oceanic crust is observed beneath the Hikurangi trough, which we attribute to the presence of pore water in the bending-induced normal faults and/or mineral alterations. A fast ($V_p \approx 8.7 \pm 0.2$ km/s) upper mantle layer lies ≈24-27 km beneath a regular mantle layer ($V_p \approx 8.0 \pm 0.2$ km/s) under the Hikurangi trough. This is consistent with several previous findings of upper mantle V_p of ≈8.7-9.0 km/s in the margin-parallel direction under the North Island (≈100 km northwest of the deformation front) at 8-10 km depths beneath the Moho. Our profile is orientated perpendicular to the margin and thus we show that not only the upper mantle lid of the subducting Pacific Plate has unusually high P_n wave speeds, but also it is azimuthally isotropic.

We interpret the increase in thickness of the regular mantle beneath the trough as a result of the formation of a low-velocity zone in the faster upper mantle layer due to serpentinisation by hydration through bending-induced normal faults, and/or due to brittle faulting along micro cracks. Thus the "regular mantle" (8 km/s) is not in fact regular, but rather the high speed mantle that has mechanically bent, faulted and/or hydrated. The absolute depth where the mantle velocity is detected is around 50 km. This is also where the bottom zone of earthquakes of the double seismic zone start under the North Island, and is typical of the depth for this zone found at other margins. Thus we provide circumstantial evidence to support the hypothesis that the lower band of earthquakes in a double seismic zone are due to dehydration processes linked to antigorite (Brudzinski et al., 2007), although we cannot reject the reduction in wave speed is due to cracks alone (Korenaga, 2017).

Other active margins where a reduction in P-wave speeds has been found include Alaska, central America and the Mariana subduction zone(Shillington, 2018). This study of the Hikurangi margin, is different in that it's an oceanic plateau undergoing bending, but the results look similar to the other areas where regular oceanic crust is subduction.

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Korenaga, J., 2017, On the extent of mantle hydration caused by plate bending: Earth and Planetary Science Letters, v. 457, p. 1-9.

Shillington, D. J., 2018, Water takes a deep dive into an oceanic tectonic plate: Nature-News and Views, v. 563, p. 335-336.