Seismic structure along transitions from flat to normal subduction: central Mexico, southern Peru, and southwest Japan

Thesis by

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Abstract

The fine-scale seismic structure of the central Mexico, southern Peru, and southwest Japan subduction zones is studied using intraslab earthquakes recorded by temporary and permanent regional seismic arrays. The morphology of the transition from flat to normal subduction is explored in central Mexico and southern Peru, while in southwest Japan the spatial coincidence of a thin ultra-slow velocity layer (USL) atop the flat slab with locations of slow slip events (SSEs) is explored. This USL is also observed in central Mexico and southern Peru, where its lateral extent is used as one constraint on the nature of the flat-to-normal transitions.

In western central Mexico, I find an edge to this USL which is coincident with the western boundary of the projected Orozco Fracture Zone (OFZ) region. Forward modeling of the 2D structure of the subducted Cocos plate using a finite-difference algorithm provides constraints on the velocity and geometry of the slab's seismic structure in this region and confirms the location of the USL edge. I propose that the Cocos slab is currently fragmenting into a North Cocos plate and a South Cocos plate along the projection of the OFZ, by a process analogous to that which occurred when the Rivera plate separated from the proto-Cocos plate 10 Ma.

In eastern central Mexico, observations of a sharp transition in slab dip near the abrupt end of the Trans Mexican Volcanic Belt (TMVB) suggest a possible slab tear located within the subducted South Cocos plate. The eastern lateral extent of the USL is found to be coincident with these features and with the western boundary of a zone of decreased seismicity, indicating a change in structure which I interpret as evidence of a possible tear. Analysis of intraslab seismicity patterns and focal mechanism orientations and faulting types provides further support for a possible tear in the South Cocos slab. This potential tear, together with the tear along the projection of the

OFZ to the northwest, indicates a slab rollback mechanism in which separate slab segments move independently, allowing for mantle flow between the segments.

In southern Peru, observations of a gradual increase in slab dip coupled with a lack of any gaps or vertical offsets in the intraslab seismicity suggest a smooth contortion of the slab. Concentrations of focal mechanisms at orientations which are indicative of slab bending are also observed along the change in slab geometry. The lateral extent of the USL atop the horizontal Nazca slab is found to be coincident with the margin of the projected linear continuation of the subducting Nazca Ridge, implying a causal relationship, but not a slab tear. Waveform modeling of the 2D structure in southern Peru provides constraints on the velocity and geometry of the slab's seismic structure and confirms the absence of any tears in the slab.

In southwest Japan, I estimate the location of a possible USL along the Philippine Sea slab surface and find this region of low velocity to be coincident with locations of SSEs that have occurred in this region. I interpret the source of the possible USL in this region as fluids dehydrated from the subducting plate, forming a high pore-fluid pressure layer, which would be expected to decrease the coupling on the plate interface and promote SSEs.

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