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Crustal structure and evolution of the southern Juan de Fuca plate from wide-angle seismic data: Insights into the hydration state of the incoming plate off Cascadia subduction zone

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Abstract:

A multi-channel seismic reflection and wide-angle refraction seismic experiment was conducted on the Juan de Fuca (JdF) plate to investigate the evolution of the plate from accretion to its subduction at the Cascadia margin. Hydration of the upper crust (UC) of the JdF Plate is well documented, but the state of hydration of the lower crust (LC) and upper mantle (UM] remains to be investigated. A 2D P-wave velocity model of the plate is derived from a joint reflection-refraction travel-time inversion of wide-angle seismic data. Stacked MCS reflection images together with modeled sedimentary velocities define an increasing thickness of sedimentary cover of up to 2.7km. Evidence for bending-related faulting is identified in coincident MCS images both indirectly as faulting in the sedimentary layer [Gibson, et al., this meeting] and directly as dipping crustal reflectors [Han et al., this meeting]. Three first order features are evident in the patterns of crustal velocity variations along the profile. 1: Crustal velocities at 150-250 km landward of the spreading ridge (~5 Ma age) show reduced velocities up to -0.20 km/s in comparison to velocities in younger crust (~3 Ma) 100-150 km from the ridge. This decrease in velocities is coincident with a propagator wake. 2: Upper crustal velocities begin to increase at 170km from the deformation front (DF), which coincides with the first evidence of faulting from sedimentary offsets. Crustal velocities start a decreasing trend at 80km from the DF where fault throws are seen to begin increasing trend landward. 3: UC velocities in the region of directly imaged crustal faulting (40km from trench) increase ~0.5km/s at the DF, while LC velocities decrease ~0.3km/s. The contrasting behavior in the upper and lower crust may indicate that bending promotes hydrothermal circulation in the outer rise. Circulation may be vigorous enough within the sediments/UC so that any residual shallow porosity is clogged with alteration products faster than new porosity created by faulting, while in the LC new faults and cracks are the dominant process increasing porosity. We present estimates of porosity from ridge to trench at crustal and upper mantle levels by taking into account thermal effects on seismic velocity in order to place bounds on total and spatial distribution of water stored in the plate.

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