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Bending-related faulting, hydration, and mantle serpentinization in the incoming Cocos Plate at Middle America Trench: Evidence from wide-angle seismic refraction data

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At subduction zones, the bending of incoming plates and associated extensional stresses resulted in strong fault activity in the crust and upper mantle. The severe fracturing of the subducting slab in the trench outer rise facilitates the entrain of seawater into the lithosphere, leading to the serpentinization of peridotite in the upper mantle. Therefore, subduction zones are an important setting, nurturing material exchange between the hydrosphere and the solid earth, affecting the water cycle.

To investigate the behavior of the subducting plate, during the experiment conducted aboard RRS JAMES COOK in the Guatemala Basin where the Cocos plate enters the Middle America Trench, we collected a wide-angle seismic refraction profile and coincident multi-channel seismic profile. Here, we present a seismic velocity model derived from a joint refraction and reflection seismic tomography using 10,508 crustal refraction arrivals, 6,533 Moho reflection arrivals, and 7,769 upper mantle refraction arrivals recorded by 37 ocean-bottom-seismometers. The spacing of instruments is ~7.5 km on the unaltered incoming plate and decreases to half of that from the outer rise into the trench. The results show that the unaltered oceanic crust is ~5-6 km thick and features a typical two-layer oceanic structure, ranging from ~4-5 km/s at the basement top to ~7 km/s at the bottom of the crust. Closer to the trench, at ~70 km away, we observe a prominent velocity reduction with lower-crustal velocities dropping to <6.8 km/s, indicating a strong impact of bend-faulting and/or hydration of the crust. However, the onset of normal faulting is observed in the coincident seismic reflection profile at ~100 km away from the trench axis. The observed faulting may indicate an evolutionary process with the progressive development of bending-related faults. At the outer rise, a seamount rising ~1 km above the seafloor is characterized by extremely low crustal velocities of only <6.5 km/s at the bottom of the crust, suggesting that the seamounts facilitate hydration. Further east, the lower crustal velocities are reduced to ~6.5-6.7 km/s beneath the outer trench wall. In the upper mantle, velocity reduction is observed ~100 km away from the trench axis and reaches its minimum beneath the seamount at the outer rise with ~7.2 km/s, which may indicate up to ~20% of mantle serpentinization. Based on our velocity

modeling results, we conclude that the intensity of bend-related faulting, hydration, and mantle serpentinization is not only controlled by the distance from the trench axis but also by seamounts ventilating the oceanic crust.