3D shear velocity structure of the northwestern South America-Caribbean Subduction Zone from ambient noise and ballistic Rayleigh wave tomography

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The Caribbean plate (CAR) collided with and initiated subduction beneath northwestern South America (SA) at about 60-55 Ma. Since the onset of subduction, it has formed the Lara nappes and subsequently the Laramide-style uplifts of the Merida Andes, Sierra de la Perija and Santa Marta ranges, with maximum elevations > 5km. The triangular Maracaibo block, bounded by the Santa Marta-Bucaramanga, Bocono and Oca-Ancon Faults, is currently escaping to the north relative to SA over both the subducting and nonsubducting elements of the CAR plate.

Although many petroleum related seismic studies have been done in this area, the details of the subduction geometry of the CAR plate beneath the Maracaibo block remain unclear. The few deeper seismic investigations are either very large scale, very local, or only peripheral to this area. Previous geodetic studies have suggested that this region has potential for a great (M~8+) earthquake (Bilham and Mencin, 2013). To investigate this complex region we fielded a 65 element broadband seismic array to complement the 48 existing stations of the Colombian and Venezuelan national seismic networks. The array is collectively referred to as the CARMArray.

In this study, we jointly inverted ambient noise Rayleigh wave Z/H ratios, phase velocities in the 8-30s band and ballistic Rayleigh wave phase velocities in 30-80s band to construct a 3D S-wave velocity model in the area from 75°-65° west and 5°-12° north. Rayleigh wave Z/H ratios are sensitive to the shallow sedimentary structure, while the phase velocity data have good resolution of the crust and upper mantle. The Vs model shows strong low-velocity anomalies beneath the Barinas-Apure and Maracaibo Basins, and the Paraguana Peninsula that are well correlated with surface geology. Sediment thickness beneath the Maracaibo basin reaches up to ~9 km depth, consistent with previous studies (Kellogg & Bonini, 1982). Crustal thickness beneath the Santa Marta uplift is 27-30 km, shallow for its nearly 4km elevation. From the trench to the southeast, Moho depth increases from 25-30 km near the coast to 40-45 km beneath the Maracaibo Basin, with the thickest crust, ~50 km, lying under the Merida Andes beneath the Bocono Fault. Crustal thickness decreases under the Venezuelan interior to ~45 km. From 50km to 150km depth, the CAR plate shows ~2% high Vs anomalies beneath the Santa Marta uplift and the Serrania de Perija range. Our slab image matches local slab seismicity very well (Cornthwaite et al., EGU 2021 GD7.1), and is consistent with and complements images from teleseismic P-wave tomography.