Evidence for Terrane Accretion, Localized Rifting and Magmatism from the Crustal Velocity Structure of the Southeastern United States

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The crustal structure in the Southeastern United States records multiple terrane accretion events, the formation of the supercontinent Pangea, widespread magmatism from the Central Atlantic Magmatic Province (CAMP), and crustal thinning before the breakup of Pangea. We use wide-angle refraction seismic data from Lines 1 and 2 of the SUGAR (SUwannee suture and GeorgiA Rift basin) seismic experiment to constrain crustal structure in order to better understand these tectonic events. The 320- and 420-km-long lines cross the Mesozoic rift basins that record crustal thinning prior to the breakup of Pangea and multiple potential suture zones between accreted terranes. We obtain models of crustal P-wave velocity structure with reflection/refraction tomography based on refractions through the sediments, crust and mantle and reflections from the base of the sediments, within the crust and the Moho. We also present a model of upper crustal Vs along SUGAR Line 2.

Vp and Vs on the northern part of SUGAR Line 2 constrain the geophysical properties of accreted terranes, the boundaries between them, and the properties of a decollement involved in orogenesis. We observe high seismic velocities within the Inner Piedmont and Carolina terranes to the north compared with the Suwanne Terrane to the south. Remarkably, crustal velocities are largely homogeneous farther south, including across the prominent Brunswick Magnetic Anomaly. These observations provide new constraints on the location of the Alleghenian suture from the most recent orogeny. The Inner Piedmont and Carolina terranes are underlain by a ~2-km-thick low velocity zone at ~5 km depth, which we interpret as meta-sedimentary rocks and/or an Appalachian detachment.

Differences in the basin structure, crustal velocities, and crustal thickness between SUGAR Lines 1 and 2 reflect contrasts in the amounts of extension and magmatism between the two Mesozoic rift segments. Line 1 has thicker and more laterally extensive syn-rift sediments and shows a more pronounced region of crustal thinning. In contrast, syn-rift sediments along Line 2 are thinner and limited to a couple of smaller basins, and the crust of Line 2 gradually thins towards the coast. The crust along Line 1 is characterized by high velocities of >7.0 km/s, which we interpret as mafic intrusions related to rifting or CAMP; in contrast, no evidence of elevated lower crust velocities are observed on Line 2. These observations suggest that Mesozoic extension and magmatism highly localized. Furthermore, new results suggest that CAMP magmatism may have been less voluminous and more localized than previous inferred.