Signatures of lithospheric evolution beneath the southeastern U.S.

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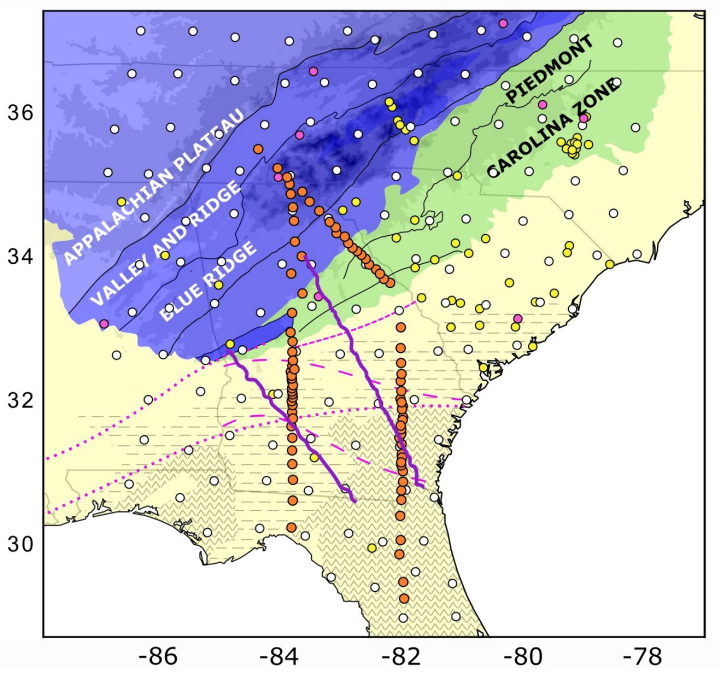
The crust and mantle beneath the southeastern U.S. record two cycles of continental accretion and rifting, followed by 250 million years of post-rifting evolution. To better understand these processes, we have applied seismic imaging methods across a wide variety of scales to data from the 85 broadband EarthScope Flexible Array stations of the SESAME array (deployed in 2010-2012 and demobilized in 2014), the EarthScope Transportable Array, and adjacent permanent stations.

In Sp stacks, a strong positive velocity discontinuity dips southward from the surface expression of the Laurentia-Gondwana suture to depths of 25-30 km. We interpret the dipping discontinuity as the contact between Gondwana crust and the crust of Laurentia and/or the previously accreted Carolina terrane. In contrast to prior studies, this geometry implies that Gondwanan crust overthrust the continental margin by more than 300 km. This crustal interface is also detected by reflections from the active source SUGAR experiment (Shillington et al.).

Sp and Ps phases clearly image thickened crust (50-55 km) beneath the Blue Ridge, the highest topography in the region, where Pn phases indicate anomalously low velocities in the uppermost mantle. These results suggest that both crust and mantle contribute buoyancy, explaining why this portion of the Appalachians is elevated despite hundreds of millions of years of erosion.

The transition from thick high velocity lithosphere beneath the craton to thinner lithosphere near the coast and passive margin is captured by Rayleigh wave tomography. Sp phases from the depth range of the lithosphere-asthenosphere transition are variable in strength, and indicate that the lithosphere-asthenosphere velocity gradient is typically gradual (>50 km) beneath the craton while more vertically localized beneath some regions of the Appalachian orogen. SKS phases provide evidence for different alignments of lithospheric and asthenospheric mantle anisotropy.

Teleseismic body-wave tomography shows an eastward dipping high velocity anomaly that extends from the base of the Grenville lithosphere into the mantle transition zone, consistent with lithospheric delamination.



Southeastern U.S. tectonic features and station locations. Broadband station locations are shown by circles (orange: SESAME; white: EarthScope TA; pink: permanent; yellow: other temporary stations.) The SUGAR experiment (Shillington et al.) is represented by purple lines. Simplified geologic terranes with topographic shading are denoted by background color (blue: Laurentian affinity; green: exotic or suspect; yellow: Cenozoic sedimentary cover). Subsurface features are also indicated (dashes: Mesozoic rift basin; carets: Gondwanan affinity Suwannee terrane). Previously inferred limits of the Laurentia-Gondwana suture zone are shown by pink lines (dotted line, from outcrop patterns; dashed line, from reflection profiling).