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Imaging crust and mantle discontinuities across tectonic boundaries in North America with Sp receiver functions

Karen M. Fischer and Emily Hopper

Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, Rhode Island, USA (Karen_Fischer@brown.edu)

When broadband stations are spaced at ∼70 km or less, as with the EarthScope Transportable Array in North America, common conversion point stacking of Sp receiver functions is capable of continuous three-dimensional imaging of velocity gradients at shallow mantle depths, provided that the gradients are localized over ∼30 km or less. In the tectonically active western United States, Sp common conversion points stacks reveal a strong and coherent negative velocity gradient (velocity drop with increasing depth) that falls within the transition from high velocity lithosphere to low velocity asthenosphere seen in surface wave tomography. This negative velocity gradient is interpretable as the seismological lithosphere-asthenosphere boundary. Its depth varies significantly across certain tectonic boundaries at horizontal length scales of less than ∼75 km, consistent with a rheologically strong mantle lithosphere in which strain can localize.

When station spacing is sufficiently dense (∼5 km) coherent imaging of discontinuities in the upper and lower crust is possible, even for Sp phases with dominant periods close to 10 s. With data from the 85 broadband stations of the SESAME array in the southeastern United States (an EarthScope Flexible Array experiment) and adjacent Transportable Array and permanent stations, common conversion point stacking of Sp phases resolves strong velocity gradients in the upper and lower crust that are continuous over hundreds of horizontal kilometers. Across the Suwannee suture (the northern edge of the Gondwanan or peri-Gondwanan Suwannee lithosphere that accreted to Laurentia in the last stages of the Appalachian orogeny) a strong positive velocity discontinuity dips southward from the surface expression of the suture to depths of 25-30 km. Modeling with common conversion point stacks of synthetic Sp phases demonstrates that Sp data can resolve the dipping discontinuity, despite the presence of sediment-filled Mesozoic rift basins and younger sedimentary cover. We interpret the dipping discontinuity as the contact between Suwannee crust and the crust of either Laurentia or previously accreted peri-Gondwanan terranes. The positive sign of the discontinuity could represent an increase in isotropic velocity between the Suwannee crust and the crust to which it accreted, or it could correspond to the base of a strongly foliated radially anisotropic crustal shear zone. In contrast to the more steeply-dipping suture previously inferred from COCORP reflection profiles, the positive discontinuity imaged by the Sp data dips southward at an angle of less than 10°. This geometry implies that Suwannee crust overthrust the continental margin by more than 300 km and that the final assembly of Pangea in this region included significant convergence.