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Tomographic Images of P- and S-wave Velocity Variations Beneath the Southern Africa Seismic Array

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The goal of this investigation is to place constraints on the morphology, composition, and evolution of a long-lived cratonic mantle keel beneath southern Africa. Specifically, we wish to place constraints on the thickness of the mantle keel, regional variations in P- and S-wave velocities in the keel region, and deeper mantle structure beneath the keel. To this end, we analyzed regional and teleseismic P- and S-wave relative delay times to obtain high-resolution tomographic images of seismic velocity structure.

We utilized waveforms recorded by the Southern Africa Seismic Experiment, a two-year deployment of over 80 broadband stations in South Africa, Zimbabwe, and Botswana. The array was one component of a multidisciplinary project conducted by the Carnegie Institution of Washington, MIT, and several southern African academic institutions and industry collaborators. Instrumentation was obtained from the IRIS/PASSCAL and Carnegie Institution of Washington seismometer pools, and data from several IRIS/GSN permanent stations provided supplemental data near the array. Numerous events were recorded from a wide range of distances and backazimuths, providing good control for resolving lateral and depth variations in mantle velocity structure.

P-wave results indicate ~±1% variation in velocities across the array, while preliminary S-wave results indicate ~±2% variation that roughly match the P-wave patterns. Upper mantle velocities beneath the Zimbabwe and Kaapvaal cratons are significantly higher than velocities beneath the surrounding Proterozoic mobile belts, and the cratonic keel appears to extend to depths of up to 300 km in some areas. In addition, a significant lower mantle low-velocity region emerges below ~700 km. One particularly interesting feature in the tomographic images is a prominent low-velocity region near the Bushveld province in northern South Africa, which may extend throughout the entire keel thickness. This result, combined with age estimations from mantle nodules in this region, suggests that significant cratonic disruption may have occurred during development of the Bushveld. We will refine S-wave images and compare P- and S-wave results to help distinguish between possible chemical and thermal effects that may produce the observed regional velocity variations beneath the array.