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Structure and extent of the southern African cratons

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We present a high resolution seismic model of the South African cratonic region from receiver function and teleseimic tomography interpretations of the P- and S- body wave data from the South Africa Seismic Experiment (Carlson et al, EOS 77, 1996) across the Kaapvaal and Zimbabwe cratons and the Bushveld complex.

Using receiver functions which we calculated by iterative deconvolution processing, we estimated Moho depth and the Vp/Vs ratio, as well as parameters describing anisotropy in the crust. The calculated strength of the crustal anisotropy is, surprisingly, comparable to the contribution from the mantle (to depth of 170 km by S. Gao 2001, JGR). Modelling with theoretical receiver functions we find a best model with an average fast polarization axis trend=30°-40°and strength reached 50% for the crustal fabric of the total 170 km deep. By stacking and analysis of the SV and SH components we find that most of the strong anisotropy is confined to the lower crust.

Using finite-frequency kernels, we inverted the P- and S- wave delay times to obtain 3-D images of compressional and shear velocity perturbations in the mantle by use of three frequency bands: 1, 0.5 and 0.25 Hz for P-waves and 0.1, 0.05 and 0.02 Hz for S-waves. All P- and S- wave arrivals were hand-processed. Crustal corrections are based on the receiver functions model. Checkerboard resolution tests show good model recovery for anomalies of size 3°x3°with Vp and Vs variations of ±0.8% and ±1.4% respectively. To isolate the depth extent of anomalies in the model we ran suites of squeezing tests. In theses tests we increased the damping parameter in the deeper layers progressively and examined the rms misfit and the imaged structure. We found that the lateral distribution of structures remains unaffected by the depth extent of the model, and that deep structures remain present for strong damping which indicates to us that the deep structures are real.

The Receiver Functions show a thin crust with a flat and sharp Moho discontinuity throughout the entire Kaapvaal and Zimbabwe cratons. These results are consistent with expectations for Archean areas but the new thing here is the P to S clear signal from the lower crust discontinuity. The lowest Vp/Vs value sites are found around the locations of diamondiferous kimberlite pipes at flat Moho in the heart of the Kaapvaal craton.

The new P- and S- wave tomography models show velocity variations between the Archean and modified regions (such as the Bushveld complex) and the mobile belts surrounding the cratons. The high velocity cratonic roots extend to 300-350 km depth beneath the Kaapvaal and Zimbabwe cratons. Smaller velocities are found under the Bushveld complex and the mobile belts. We also suggest a stratified structure as we found a low velocity zone (LVZ) which may be interpreted as mid-lithospheric discontinuity (MLD) at about 170 km depth in the cratonic areas. The LVZ is currently under by SdP receiver functions and in the future by surface wave tomography.