Geophysical Research Abstracts
Vol. 15, EGU2013-4980, 2013
EGU General Assembly 2013

Shear velocity and anisotropy distributions beneath southern Africa's cratons: Lithospheric structure, deformation, LAB and other discontinuities

Joanne Adam (1,2) and Sergei Lebedev (1)

(1) Dublin Institute for Advanced Studies, Dublin 2, Ireland (joanne@cp.dias.ie), (2) Department of Geology, Trinity College Dublin, Dublin 2, Ireland

Seismic-velocity structure and anisotropy of cratonic lithosphere offer important clues on the enigmatic formation and stabilization of cratons. Broad-band surface waves are highly sensitive to both the isotropic-average shear speeds from the upper crust down to the asthenosphere (characterising the composition and thermal state of the lithosphere) and to radial and azimuthal shear-wave anisotropy (indicative of ancient and recent deformation and flow). Recently, receiver function studies have yielded exciting but puzzling new evidence, revealing multiple discontinuities at different depths within the lithosphere-asthenosphere depth range beneath cratons. While some of the receiver-function signals probably indicate the lithosphere-asthenosphere boundary (LAB), others must be due to sharp radial changes in the mantle-rock composition or anisotropy.

We have recently used teleseismic interferometry to measure thousands of inter-station, Rayleigh- and Love-wave, phase-velocity curves across southern Africa (Adam and Lebedev 2012). Here, we invert the very-broadband dispersion data for the profiles of the shear speed and azimuthal and radial anisotropy beneath different parts of the Kaapvaal Craton and the Limpopo Belt. Systematic model space mapping is used to evaluate parameter trade-offs and to ensure the robustness of the anisotropy profiles.

Our results, firstly, reconcile the long-debated previous models based on different interpretations of SKS-splitting measurements in southern Africa (one end-member model placing anisotropy primarily into the lithosphere and attributing it to Archean deformation and the other placing it into the asthenosphere, with recently developed fabric). We show that the depth distribution of anisotropy comprises elements of both models: anisotropy in the asthenosphere shows fast-propagation directions parallel to the plate motion; anisotropy in the Limpopo and northern Kaapvaal lithosphere shows fast directions parallel to the Archean–Paleoproterozoic sutures. The distribution of SKS-splitting orientations across southern Africa reflects anisotropic fabric both within the lithosphere (dominating the splitting beneath the Limpopo Belt and northern Kaapvaal Craton) and within the asthenosphere (dominating beneath the western Kaapvaal Craton).

Secondly, our results reveal the layering of shear speed anomalies and anisotropy within the lithosphere. We interpret this jointly with published receiver-functions from the region, which suggest the presence of interfaces at around 100, 200 and 300 km depths. Significant high-velocity anomaly characteristic of cold cratonic lithosphere is constrained by surface waves and bottoms at around 200 km depth; the S-to-P conversions at this depth can thus be attributed to the LAB. At around 90-100 km depth, surface-wave data require substantial changes in fast-propagation directions beneath the Kaapvaal Craton. Because the anisotropic fabric is a record of flow during the last episode of pervasive deformation experienced by the rock, its differing orientations in the upper and lower parts of the mantle lithosphere have important implications for the mechanism of the formation and stabilization of the craton. The discontinuity at 90-100 km seen in receiver functions can thus be attributed to the relatively sharp radial change in anisotropy at this depth, evidenced by the surface-wave data.

Adam, J. M.-C., Lebedev, S., 2012, Azimuthal anisotropy beneath southern Africa, from very-broadband, surface-wave dispersion measurements, Geophys. J. Int., 191, 155-174.