Geophysical Research Abstracts
Vol. 14, EGU2012-8761-7, 2012
EGU General Assembly 2012

Why is the Kaapvaal different from other cratons?

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The unique chemical and physical properties of the Archean tectosphere make it a prime target for seismological investigation. We use the results from high-resolution seismic imaging of upper mantle structure beneath southern Africa to argue that the Kaapvaal craton is different from other cratons in terms of the crustal and lithospheric mantle structure.

We find evidence that the crust is compositionally unique: (1) We observe evidence for a slower velocity of the lower crust than in other Archean cratons, and we suggest a granitoid composition instead of the expected mafic-ultramafic chemistry. (2) We further observe, for the first time, strong azimuthal anisotropy in the lower crust by receiver function analysis. The current study is based on high-quality data from the SASE experiment [Carlson et al., 1996] which provides, because of its good coverage and dense array, precise measurements of cratonic crustal anisotropy. Our reinterpretation of the crustal structures indicates the existence of a metamorphosed (mica-foliated gneiss) layer that separating the felsic upper crust from the intermediate (granitoid gneiss) lower crust. These results indicate significant difference between the Kaapvaal crust and the crust of other African cratons.

We have examined the upper mantle with finite-frequency (BDK) tomography and Ps receiver function analysis. The receiver functions indicate that there is a structural boundary in the lithospheric mantle beneath the Kaapvaal at relatively shallow depths (170 km at the edges to 220 km deep within the central part of Kaapvaal), which cannot be interpreted as the lithosphere - asthenosphere boundary, as inferred from previous seismic tomography and other geophysical studies. Our results from the BDK tomographic inversion suggest thicker cratonic lithosphere (up to $\sim$ 350 km) here than elsewhere on the globe as revealed by seismic tomography.