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Published in:
Geophysical Research Abstracts

Publication date:
2013

Document version
Early version, also known as pre-print

Citation for published version (APA):
Youssof, M., Thybo, H., Levander, A., & Artemieva, I. (2013). Seismic velocity structure and anisotropy in southern African lithosphere terranes. *Geophysical Research Abstracts*, *15*.

Geophysical Research Abstracts
Vol. 15, EGU2013-7804-2, 2013
EGU General Assembly 2013

Seismic velocity structure and anisotropy in southern African lithosphere terranes

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Receiver function (RF) has sufficient depth resolution to identify variation in azimuthal anisotropy in lithospheric layers of the cratons [Yuan and Romanowicz, 2010; Vinnik et al., 2012].

However, crustal anisotropy has, so far, been assumed to be insignificant and thus has never been addressed in the seismic models for the southern African cratons. Silver et al. (2001) estimated crustal anisotropy by Ps converted phases for core arrivals for about half of the South Africa Seismic Experiment (SASE). They estimate that less than a quarter of the total anisotropy for core phases may reside in the crust.

In this study, our RF analysis from all 82 SASE station reveals, for the first time, strong azimuthal anisotropy in the cratonic lower crust. The crustal contribution to the total S-wave splitting is 30% on average, and up to 40% of the total anisotropy determined by SKS splitting measurements.

Here we introduce the effects of crustal anisotropy on the time delay corrections in order to improve body wave tomography models.

To avoid projection of crustal velocity into the mantle, we apply crustal and elevation corrections to the delay times. Ray theoretical time corrections are calculated based on a crustal model derived from the results of our RF calculations including effects of anisotropy [Youssof et al. submitted]. This RF crustal model consists of linear velocity gradients in two crustal layers: a uniform felsic isotropic upper crust underlain by an anisotropic intermediate lower crust. The rms of the corrected traveltime of the P- and S-waves is 0.3255 s and 0.5770 s, while the crustal corrections have rms of 0.1204 s and 0.1153 s for P- and S-waves, respectively.

Finite frequency tomography suggests that the variation in velocity perturbations between the cratons and surrounding areas is about 0.8%. In contrast to previous studies we find that the mantle of the Limpopo Belt has a negative velocity anomaly, which is comparable in magnitude to the mantle of the Bushveld complex. Mantle heterogeneities could anomalously reduce the seismic velocity due to fertile patches in the mesh medium [Anderson, 2006]. Hence, we suggest that the Limpopo belt may include considerable amount of impurities in the mantle with low seismic velocities in the depleted body that can cause the relative low anomalies.