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Absolute Plate Velocities from Seismic Anisotropy

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The orientation of seismic anisotropy inferred beneath plate interiors may provide a means to estimate the motions of the plate relative to the sub-asthenospheric mantle. Here we analyze two global sets of shear-wave splitting data, that of Kreemer [2009] and an updated and expanded data set, to estimate plate motions and to better understand the dispersion of the data, correlations in the errors, and their relation to plate speed. We also explore the effect of using geologically current plate velocities (i.e., the MORVEL set of angular velocities [DeMets et al. 2010]) compared with geodetically current plate velocities (i.e., the GSRM v1.2 angular velocities [Kreemer et al. 2014]).

We demonstrate that the errors in plate motion azimuths inferred from shear-wave splitting beneath any one tectonic plate are correlated with the errors of other azimuths from the same plate. To account for these correlations, we adopt a two-tier analysis: First, find the pole of rotation and confidence limits for each plate individually. Second, solve for the best fit to these poles while constraining relative plate angular velocities to consistency with the MORVEL relative plate angular velocities. The SKS-MORVEL absolute plate angular velocities (based on the Kreemer [2009] data set) are determined from the poles from eight plates weighted proportionally to the root-mean-square velocity of each plate. SKS-MORVEL indicates that eight plates (Amur, Antarctica, Caribbean, Eurasia, Lwandle, Somalia, Sundaland, and Yangtze) have angular velocities that differ insignificantly from zero. The net rotation of the lithosphere is 0.25 ± 0.11º Ma^{-1} (95% confidence limits) right-handed about 57.1ºS, 68.6ºE. The within-plate dispersion of seismic anisotropy for oceanic lithosphere (σ=19.2°) differs insignificantly from that for continental lithosphere (σ=21.6°). The between-plate dispersion, however, is significantly smaller for oceanic lithosphere (σ=7.4°) than for continental lithosphere (σ=14.7°). Two of the slowest-moving plates, Antarctica (v_{RMS}=4 mm a^{-1}, σ=29°) and Eurasia (v_{RMS}=3 mm a^{-1}, σ=33°), have two of the largest within-plate dispersions, which may indicate that a plate must move faster than $\approx$5 mm a^{-1} to result in seismic anisotropy useful for estimating plate motion.

We will investigate if these relationships still hold with the new expanded data set and with the alternative set of relative plate angular velocities.

We have found systematic differences between the SKS orientations and our predicted plate motion azimuths underneath the Arabia plate, which suggests to us either plate-scale mantle flow process not directly associated with that plate's absolute motion or intrinsic lithospheric anisotropy. We will discuss more of such discrepancies underneath other plates using the enlarged data set.