Whole Mantle Vp/Vs Tomography

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Understanding of tomographic image in terms of dynamics of the Earth's interior requires knowledge of what causes lateral variation of seismic wave velocities. One way of distinguishing origins of heterogeneity is to compare observed tomographic velocity anomalies to those predicted by mineral physics. The purpose of this study is to model three-dimensional Vp/Vs ratio variation which is suitable to be measured for laboratory experiments but rarely derived seismologically. Modeling is made using broadband S-P differential travel times, which carry P and S information along similar ray paths with little bias from origin time determinations. The Vp/Vs tomographic model so derived can be directly compared to laboratory measurements.

Picking S wave arrival is in general a difficult task, which is often overcome by waveform correlation technique. Since our primary interest is S-P differential travel time, rather than S arrival time, we cross-correlate the observed S waveform with that synthesized from the observed P waveform by correcting the attenuation effect, which is characterized by two parameters $t*$and fo. The reference frequency fo is conventionally set to 1 Hz, with which we, later, found a systematic discrepancy of about 0.5 s between the cross-correlated and handpicked S-P times. This discrepancy disappears when the reference frequency is taken to be 2 Hz, indicating that 2 Hz is more appropriate than 1 Hz as the reference frequency of teleseismic body waves. We obtained about 15,000 S-P times using this reference frequency.

Vp/Vs tomography can be modeled by the use of measured S-P times and highly-resolved P tomography of Fukao et al., [2001]. The consistency of our handpicked P times and the predicted travel times of their model enables us to solve for Vp/Vs diffraction as a linear inverse problem. Using the result of the obtained Vp/Vs tomography and the P velocity model, a three-dimensional S distribution can be derived as Vs = Vp / (Vp/Vs). These models are compared to each other to find regions which, for instance, are anomalously slow in S wave, yet are very different in terms of Vp/Vs ratio. We also apply our inversion technique to obtain a three-dimensional distribution of R, the ratio of fractional S-velocity perturbation to fractional P-velocity perturbation.