The effect of P-wave velocity on the ellipticity of Rayleigh waves in a transversely isotropic medium

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The study of surface waves is one of effective approaches for the internal structure of the earth. Phase and group velocities data have ever been used, but the ellip- ticity of Rayleigh waves can be also used to infer it (e.g., Tsuboi & Saito, 1983) . The ellipticity of Rayleigh waves is defined as a V(vertical amplitude)/H(horizontal amplitude) ratio, which is more sensitive to shallow structures than the conventional phase or group dispersion data. Fundamentally, it is the same principle as strong ground motions with horizontal and vertical amplitudes of microtremors to evaluate near-surface structures easily. Tsuboi & Saito (1983) and Tanimoto & Tsuboi (2009) derived and calculated partial derivatives of ellipticity in an isotropic medium. In addition to the well-known anisotropy in the asthenosphere such as that included in PREM, the influence of a transversely isotropic medium may be important for shallow structures such as a sedimentary layer. A transversely isotropic medium has five elastic moduli (A, C , L, N .F) but propagations of surface waves can be formulated in a compact manner, similar to the isotropic case.
In this study, we first formulated partial derivatives of ellipticity in a transversely isotropic medium. In the same way as the isotropic medium, we determine the linear relationship using the variational principle and the reciprocal theorem. Then, we set an artificial eigenfunction for the boundary condition of non-zero normal stress at the surface in addition to the natural eigenfunction for the normal condition (i.e., zero stress at the surface). We then derived partial derivatives with the two kinds of eigenfuncitons combined. Several important features of PV-waves and PH-waves are revealed in comparison with those of P-waves in the isotropic case. P-waves have little effects on the ellipticity in an isotropic medium. In the transversely isotropic medium, partial derivatives of PV wave are quite different from those of PH wave with a relatively large amplitude in a shallow part. The reason of the small P-wave effect in the isotropic case comes from the sum of those of PV and PH waves of opposite signs. PH wave in a shallow part has a large positive effect on ellipticity while PV wave has a weak negative one. If there is a strongly laminated sedimentary layer near the surface, for example, the ellipticity does not vary so much, despite of small SV there. It is because the shallow PH velocity is not reduced in such a layer, in contrast with small SV and PV waves, and its partial derivatives is large and of the sign opposite to SV and PV waves. If we performed the inversion for the shallow structure with the data of ellipticity (i.e., only slightly anomalous), under the isotropic model with the dominance of SV wave velocity, the inversion result would lead to slightly small SV velocity near the surface with virtually no changes in P-wave velocity because partial derivatives in the isotropic case are large for SV but small for P wave.

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