Anelastic lateral heterogeneity in the lower mantle inferred from analysis of Earth's free oscillations

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[Introduction]

Lateral heterogeneity in anelastic structure is important to infer temperature structure of Earth, since anelasticity has a selected sensitivity toward high temperature anomaly. However there are some difficulties in determining anelastic lateral heterogeneity from analysis of seismic waves, so that study on global lateral heterogeneity in anelastic structure is even now inadequate compared to that on elastic structure. Furthermore previous studies have attempted only to the structure of the upper mantle; global lateral heterogeneity in anelastic structure has not yet been obtained for the lower mantle.

In this study, to infer the anelastic lateral heterogeneity in the lower mantle, we obtained the complex structure coefficients of the spheroidal modes 1S8, 1S9 and 1S10 of Earth's free oscillations whose sensitivity is quite high in the lower mantle. The complex structure coefficients are uniquely decomposed into elastic and anelastic parts, and they represent elastic and anelastic lateral heterogeneity at depths where the mode is sensitive, respectively.

[Method]

We used VHZ channel records of noise-less broadband seismic stations belonging IRIS/GSN or GEOSCOPE after 27 large earthquakes which occurred after 90's and whose seismic moments were lager than 10^27 Nm.

We measured apparent complex frequencies of these modes by applying the Sompi method (Hori et al., 1990), and complex structure coefficients were estimated from the observed apparent complex frequencies by using a non-linear inversion method (Shibata et al., 1992). To derive little trade-off of these parameters and obtain stable result, we added a damping scheme to the inversion, constrained amplitudes of structure coefficients. We performed intensive synthetic tests and confirmed that spherical harmonic degree-2 of anelastic lateral heterogeneity could be resolved by our inversion method from the observed data.

[Result]

In the spectral analysis, number of records from which apparent complex frequencies were measured were 305, 212, 184, for 1S8, 1S9, 1S10, respectively. About 26 % of them were multi-apparent complex frequencies measured for these modes. One or two apparent complex frequencies measured in once measurement constituted data sets of the inversion.

We obtained consistent degree 2 and 4 patterns among the three modes for elastic structure from inversion of the observed data. For anelastic structure, the degree 2 patterns were well correlated between 1S8 and 1S9, but that of 1S10 was different from these patterns.

[Discussion]

Elastic lateral heterogeneity indicates low-frequency anomalies beneath the Pacific Ocean and the Africa, where two superplumes are upwelling. Comparing elastic heterogeneity of our result with former studies (Resovsky and Ritzwoller, 1998; He and Tromp, 1996), they totally consisted, but our result did not have predominant degree 2 components as former studies had.

The degree-2 pattern of the anelastic lateral heterogeneity from 1S8 and 1S9 indicates low-attenuation anomalies beneath the Indonesia and the South-America, where slabs penetrate the 660 km discontinuity and continue to the depth of 1300 km.

If temperature structure in the lower mantle is simple degree two patterns, elastic and anelastic structures will show a simple one-to-one correlation, which cannot explain the present result, as same as in the upper mantle. That apparent inconsistency may result from existence of complex higher-degree temperature heterogeneity in the lower mantle and the difference in the temperature dependence between elastic and anelastic structures.