An interpretation of the coda site amplification factor based on the daylight imaging method

Hisashi Nakahara[1]

[1] Geophysics, Science, Tohoku University

The coda site amplification factor is widely used as a stable estimator of a site amplification factor for a site. Though some of the characteristics are well known, the physical meaning seems to be still unclear. In this study, we propose an interpretation of the coda site amplification factor based on the idea of the daylight imaging method. The daylight imaging method is one of the passive imaging techniques, the name of which originates from a fact that we can see objects in daytime with reflected or scattered sunlight from the objects.

Claerbout (1968) proved that a reflection seismogram can be obtained from the autocorrelation function of a transmission record, which is a usual observed seismogram, for horizontally layered media. More strictly, the autocorrelation function of a transmission record is proportional to the sum of a reflection seismogram and its time-reversed record and the delta function. The paper may be an origin of the daylight imaging method. Recently, Wapenaar (2003) extended the geometry to 3D heterogeneous media and proved that the Green's function between two receivers on the surface can be retrieved from the cross correlation function of a transmitted wave field at the receivers. For the case, incident waves are expected to come from various directions.

In the present study, we imagine that we approach one receiver on the surface to another so that the two receivers overlap in a 3D heterogeneous medium. In such a case, the Green's function between a collocated source and receiver, which is equivalent to a zero-offset reflection seismogram, may be retrieved from the autocorrelation function of a transmitted record. For making the statement more accurate, the usage of coda waves is desirable because coda waves are usually incident from various directions. Based on the Wiener-Khintchine's theorem, the power spectrum of an observed seismogram, especially for coda-wave parts, is proportional to the Fourier transform of the sum of a zero-offset reflection seismogram and its time-reversed record and the delta function. This is a physical interpretation of the coda site amplification factor. Therefore, the coda site amplification factor bears the information as if the reflection survey were done at the site.

The fact that the site amplification factor bears the information as if the reflection survey were done at the site was already mentioned for horizontally layered media by Scherbaum (1987). However, the present study is the first for 3D media. For 3D media, the usage of coda waves is desirable for their wide range of incident angles. It was Aki-sensei that first pointed out the practical importance of the coda site amplification factor based on the compilation of many observed seismograms as early as in 1960's.