SH coda wave envelopes in 2-D media with cavities (2): Diffusion Model

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In our preceding study (2003 JEPSJM, S047-001), we investigated SH wave envelopes in 2D media with many cavities, both theoretically and experimentally. The experiments were performed using a boundary integral method (Benites et al., 1992); we randomly distributed many circular cavities inside a rectangular area, let plane Ricker wavelets be incident on its bottom end from below, and synthesized seismograms at stations arrayed along the top end. We then took the RMS of the seismograms along the array to obtain an envelope. The envelope syntheses were then compared with the solutions of two popular models: the Single Isotropic Scattering Model (Sato, 1977; hereafter SISM) and the Energy Flux Model (Korn, 1990; hereafter EFM). It was shown that SISM is valid only for the cases when single scattering is dominant (very sparse cavity distribution and/or early coda), as expected. In contrast, the EFM solution was shown to coincide generally with the syntheses after some lapse times; the times tend to be shorter for denser cavity distribution and/or higher frequencies. In this study, we derive a solution of the Diffusion Model (Wesley, 1965; hereafter DM) and compare it with the same experimental results.

DM is a model based on the assumption that the seismic energy flow obeys a diffusion equation, known to be valid when multiple scattering is dominant in contrast to SISM. Here we derive an approximate DM solution that satisfies the geometrical conditions of the experiments, under the assumption that the area size (length or width), D, is much larger than the mean free path for scattering, L0. Compared with the experimental results, this solution coincides well with the EFM solution for most cases examined (the cavity volumetric concentrations being 1~20%, wavelengths 0.8d~6.7d, and D/L0 less than 4, where d is the cavity diameter). Hence the previous conclusions for EFM is valid also for DM (Figure). Though the present DM solusion is based on the assumption that D/L0 is sufficiently large as stated above, it agrees with the experimental results even for D close to L0; thus one may say it is practically valid for D/L0 larger than 1.

Theoretically, the good coincidence between the EFM and DM solutions is gradually lost as D/L0 exceeds 5. Assuming the DM solution to be true, this roughly gives the validity limit of EFM. Since the mean free paths in the lithosphere are thought to be of order of 100km (Sato & Fehler, 1997), it may be within the validity range of EFM.

References

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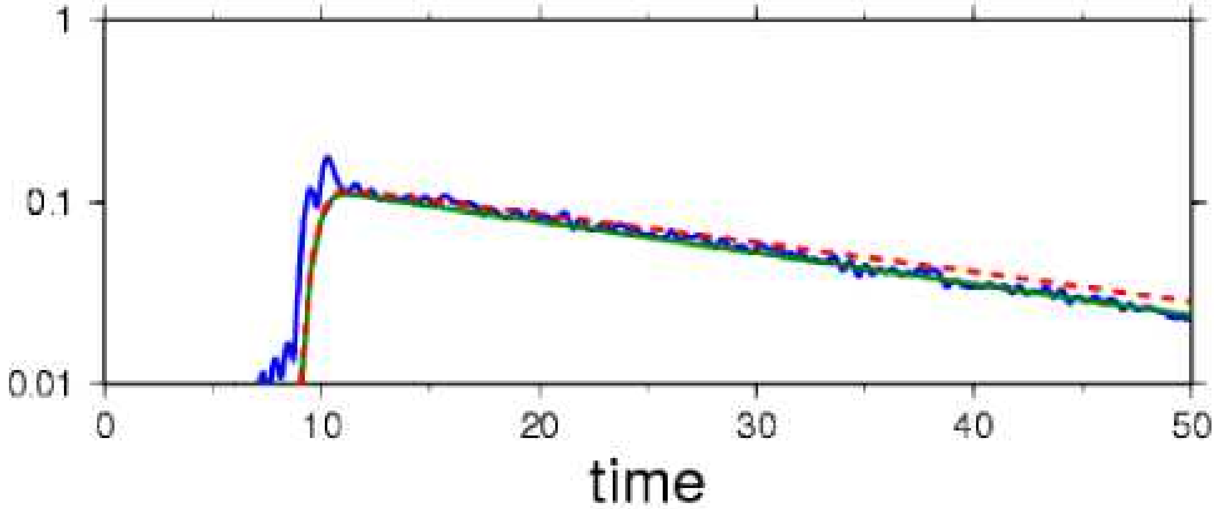

Figure. Example of SH wave envelopes. Here the cavity volumetric concentration is 20.7%, the dominant frequency is 0.6, and D/L0 is about 3. The cavity diameter and the S wave velocity of the media are assumed to be unity.

Blue line: synthesized RMS envelope.

Green line: solution of the Energy Flux Model.

Red dotted line: the solution of the Diffusion Model.