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SH coda wave envelopes in 2-D media with inclusions

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In our previous studies [1], we investigated SH coda wave envelopes in 2-D media with randomly distributed circular cavities, both theoretically and numerical-experimentally. We synthesized root-mean-square (RMS) wave envelopes and compared them with the predictions by four theoretical models: the Single Isotropic Scattering Model (SISM), the Energy Flux Model (EFM), the Diffusion Model (DM), and the Radiative Transfer Theory (RTT) [2]; we thus discussed their validity. Though cavities were treated as a simplified model of the inhomogeneous lithosphere with sharp interfaces, we treat here inclusions instead as a more realistic model of the inhomogeneity. The wave-velocity and/or mass-density contrasts between the inclusions and the matrix are assumed to be relatively small (say, 20% difference).

The simulation models are nearly the same as those used in our recent study [3]. First, let 2-D circular inclusions be embedded randomly (but without overlapping) inside a rectangular region in an otherwise homogeneous matrix. Each inclusion has the wave velocity and mass density different from those of the matrix. Following Sato and Fehler [2], assume that the relative density difference is 0.8 times the relative velocity difference for each inclusion. Next, let a plane Ricker wavelet be incident on one side of the region, and simulate the scattering therein, using a boundary integral method [4,5]. Seismograms at receivers arrayed along the opposite side are thus synthesized. Finally, calculate the RMS envelopes of the seismograms. Each theory to be compared with these envelopes is modified so as to closely match the geometry of the present simulation models [1]. The total scattering coefficient [2] included in SISM is given using the differential scattering cross sections of inclusions in the 90-degree direction, considering the predominance of single wide-angle scattering. The Q values in SISM and EFM are estimated on the basis of the Foldy-approximation theory [3]. In DM and RTT, we assume isotropic scattering, whose strength is determined by the transport cross sections of inclusions.

Let now L, l_m, t, and t_m be the propagation distance, the transport mean free path, the lapse time, and the transport mean free time, respectively. In our previous studies on cavities [1], we concluded that (i) SISM is valid if both L/l_m and t/t_m are smaller than 1, (ii) DM is valid if both L/l_m and t/t_m are larger than 1, (iii) EFM is a good approximation of DM if L/l_m is in between 1 and 5, and (iv) RTT is valid on the whole, with some exceptions such as early coda. In the present study, L/l_m and t/t_m are less than 1 throughout. The results shows that (a) both EFM and DM completely disagree with the synthesized envelopes, as expected; however, (b) SISM largely underestimates the coda envelopes for relatively high frequency, and (c) RTT seems to work only for rather high-frequency late coda. These results may be closely related to the anisotropy of scattering by low-contrast inclusions, which is stronger than that of scattering by cavities.

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