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Strongly Frequency-Dependent Intrinsic and Scattering Q for the Western Margin of the Sichuan Basin, China, as Revealed by a Phenomenological Model

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Abstract—Through applying the energy-flux model to teleseismic P-wave data, seismological scattering Q and intrinsic Q for the western margin of the Sichuan basin in southwestern China are estimated separately. The results exemplify the frequency-dependent Q values in the seismic frequency band. The scattering Q is heavily frequency-dependent and reaches a minimum at $\sim$1.5 Hz. The intrinsic Q is nearly invariant for frequencies above 2 Hz and rapidly increases at lower frequencies. A major advantage of the energy-flux model is that it is a phenomenological model based on the conservation of energy and requires no geometrical spreading correction. The results are good counterexamples against the claim of a frequency-independent seismological Q.

Recently, Morozov (2010) argued that the frequency-dependent Q predicted by theoretical studies and observed in numerical modeling and laboratory experiments could not be considered as rigorous proof for the presence of frequency-dependent seismological Q. He also argued that traditional methods for attenuation estimates based on the concept of wavefronts or rays generally presumed simple but "insufficiently accurate" geometrical spreading and thus the observed frequency dependence of seismological Q resulted from inaccurate compensation for geometrical spreading. Morozov preferred phenomenological models to traditional methods, because "phenomenological models do not require detailed descriptions of the mechanisms of the wave processes but may be based on some general principles, such as the conservation of energy and time/spatial continuity." Here we present a counterexample with strong frequency-dependent Q using a phenomenological model called the energy-flux model. This model, first proposed by Frankel and Wennerberg (1987) and further developed by Langston (1989) and Korn (1990), is based on the conservation of energy. The model predicts that the scattering Q can be determined by the coda level relative to the direct arrival and the coda Q by the decay rate.

The teleseismic P wavefields used in our analysis were recorded by an array consisting of 17 three-component stations deployed in the western margin of the Sichuan basin. The data selection and processing strategies are similar to those of Hock and Korn (2000). The values of scattering Q and intrinsic Q at different frequencies are plotted in Fig. 1. It is shown that both the scattering Q and intrinsic Q are strongly frequency-dependent. Note that Fig. 1b actually shows the coda Q. It is equivalent to the intrinsic Q when the leakage of energy into the lower half space is negligible. Even if not negligible, the intrinsic Q shares a similar variation pattern against frequency as the coda Q, just somewhat higher in quantity (see Korn, 1990 for detailed discussions).

Indeed, sometimes frequency-independent seismic Q is observed, but it is confined to restricted areas and/or frequency bands. For instance, as one can see from Fig. 1b, the intrinsic Q at frequencies above 2 Hz appears invariant within the error limit. We also found that for the Longmenshan area, which is next to the western margin of the Sichuan basin, the intrinsic Q is nearly constant for the frequency band from 0.5 to 5 Hz (not shown here). However, it is arbitrary to make a conclusion that a frequency-independent Q is valid for the whole seismic frequency band and spatially widespread.

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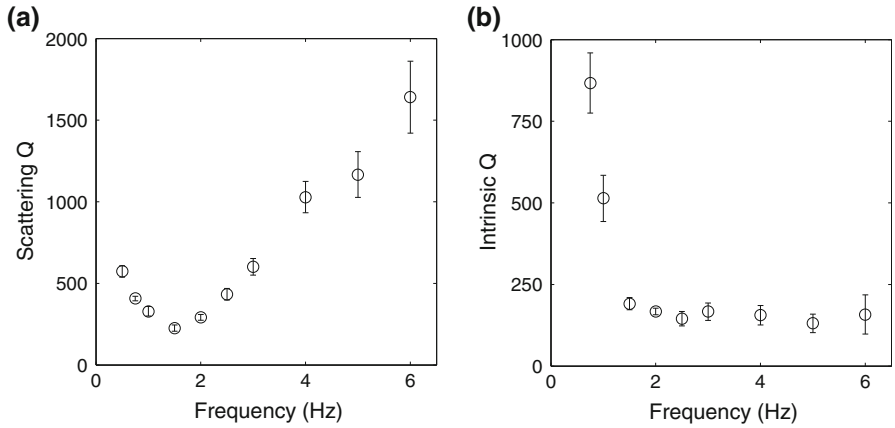

Figure 1
Plots of the frequency-dependent scattering Q (**a**) and intrinsic Q (**b**) for the western margin of the Sichuan basin

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