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# Separation of Geometric Spreading, Scattering and Intrinsic Attenuation Effects in a VSP

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## Abstract

Analysis of seismic attenuation helps understanding the lithology, physical state, fracturing, fluid and gas content of reservoir rock. The phenomenological attenuation parameters (the Q factor and also the geometric attenuation in our recent studies) are often measured by using direct waves, reflections, and acoustic logs. However, a major challenge of this analysis consists in separating the effects of intrinsic attenuation from those related to scattering on fine layering, and also to the uncertainties and variations of geometric spreading. A difficult question is how to characterize the ‘random’ and ‘non-random’ parts of scattering for a specific zone of interest. Such characterization can be achieved by detailed modeling of elastic scattering by using real well-log information.

Here, models of scattered seismic wavefields are derived for our recent study of direct-wave attenuation in a VSP in Weyburn oilfield in Saskatchewan. Oblique-angle P and S wave scattering is modeled by numerical and analytical methods by using the complete well logs. Numerical results are in good agreement with predictions from localization theory. Both approaches reveal strong fluctuations in the transmitted-energy flux within different depth intervals, and particularly at frequencies above 60 Hz. The key difficulty appears to be how to treat these fluctuations when measuring the averaged ‘scattering attenuation’ for a particular sequence of reflectors. Randomization of the well log suggests that the upper envelope of the transmitted energy flux (the envelope corresponding to strongest transmission) is a reasonable estimate for the attenuation caused by random scattering. The lower envelope (strongest reflectivity) and the median might also be useful characteristics of fluctuations in the scattered wavefields. Once the ‘scattering’ and ‘fluctuation’ attenuation is modeled, it can be isolated from the intrinsic and geometric ones. The results from Weyburn VSP show that the geometric spreading, fluctuations and internal friction are primarily responsible for the observed amplitude decays.