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Multiple Scattering of Seismic Signals at Merapi Volcano (Java, Indonesia) — Results of an Active Seismic Experiment — (Extended Abstract)

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One of the major problems in understanding the physical sources of natural seismic events at active volcanos is the separation of source and path effects. To solve this problem at Merapi Volcano (Java, Indonesia) we examined the seismic structure by an active seismic experiment. We recorded the signals of shots from 3 different source locations along 3 seismic profiles each consisting of up to 30 3-component seismometers with a station spacing of 100 m.

The observed direct P- and S-waves are attenuated strongly and show only small amplitudes. Following the weak first onset the amplitude is slowly and continuously increasing until a maximum of energy much delayed behind the direct waves. This unusual envelope of the seismograms can be explained by strong multiple scattering, where the energy of the direct waves is almost completely converted into multiple scattered energy. Not only the envelope but also the coherency and the polarization properties of the wave field indicate strong scattering. Only the first onset shows coherency over a station spacing of 100 m, whereas the later phases carrying the major part of energy are mainly incoherent (Figure 1). The azimuth of polarization is almost arbitrary corresponding to waves arriving from scatterers in different directions.

Based on an inversion using the diffusion model we obtain values of the S-wave quality factor Q_s for scattering attenuation in the order of 1.3 to 11 (depending on frequency), whereas the quality factor Q_i for intrinsic attenuation is between 68 and 288. The mean free path $1/\eta_s$ for S-waves is as low as 100 m. This points out that in a distance of a few hundreds of meters we have to take into account effects of multiple scattering. The scattering coefficient is independent of frequency ($\eta_s \sim f^{0.0}$), whereas the coefficient of intrinsic attenuation increases with increasing frequency ($\eta_i \sim f^{1.6}$).

The natural seismic events at Merapi volcano shows similar characteristics compared to the artificial shots. The first onsets have only small amplitudes and the maximum of energy arrives delayed compared to the direct waves. These signals are probably also strongly effected by multiple scattering.

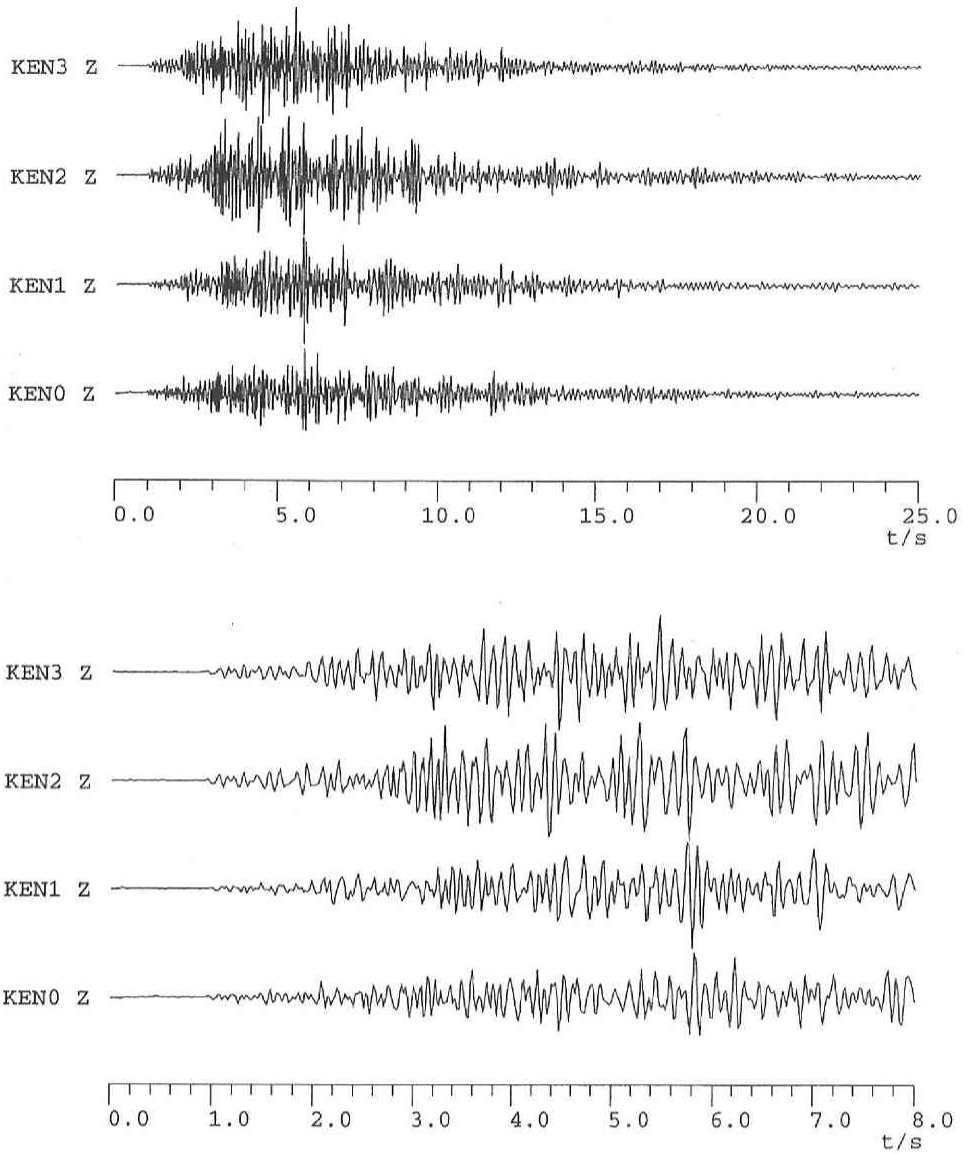

Fig. 1. Seismogram example demonstrating the diffusive character of the signals: Vertical component of shots from one artificial source recorded at the monitoring array KEN in an offset range between 2.218 km (KEN3) and 2.463 km (KEN1). The mean distance between the stations is about 150 m. Top: 25 s window. Bottom: the first 8 s.