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Microearthquake Fracture Properties and Fluid-Driven Lubrication Processes Along a Complex Normal Fault System in Southern Apennines, Italy

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We analyzed the P- and S-wave displacement spectra of 700 microearthquakes in the moment range 4×10^9 - 2×10^{14} Nm and recorded at the dense, wide-dynamic range, seismic networks operating in southern Apennines (Italy). Source parameters are estimated by a parametric modeling approach which is combined with a multi-step, non-linear inversion strategy.

In the analyzed frequency range (0.4-50 Hz), statistical tests show that the constant-Q, attenuation model has to preferred to frequency dependent Q-models, both for P- and S-waves. Consistent estimates of the attenuation parameter t*=T/Q are obtained from the spectral decay of small earthquakes below the corner frequency and from the inversion of displacement spectra of relatively larger magnitude events.

A crustal Q_S higher than Qp and a Qs/Qp greater than 1 is found in the same depth range where high Vp/Vs and a peak in seismicity distribution are observed. This is the evidence for a highly fractured, partially fluid-saturated medium embedding the Irpinia fault zone, down to crustal depths of 15-20 km.

A nearly constant stress drop (8.3 MPa) and apparent stress (3.1 MPa) scaling of P- and S-corner frequencies and seismic energies is observed above a seismic moment value of about 10^{11} Nm. Below this value the corner frequencies and seismic energy are not measurable, due to the instrument band-limitation and noise effect at high frequencies.

The ratio between apparent stress and static stress drop (Savage-Wood seismic efficiency) is relatively high (0.5), indicating that the radiated energy is a very large fraction of the sum of energies spent by friction and fracture development. It remains approximately constant over about four orders of magnitude, indicating that apparent stress and static stress drop co-varies, independently on the fracture size, at least in the explored magnitude range.

Seismic efficiency appears to be higher in the same depth range where high Vp/Vs and Qs/Qp values are also observed. This suggests that dynamic weakening driven by crustal fluid pressurization is the most plausible mechanism controlling the seismic radiation from microearthquake ruptures along the studied fault zone.