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Volcanic seismic earthquakes at Mount St. Helens exhibit a constant seismically radiated energy per unit size.

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The destructive nature of volcanic eruptions and the attenuating properties of the volcanic edifice make inferring the source properties of volcanic seismic events from waveforms a daunting task. Here we exploit the short source-receiver distances of a temporary deployment in September 2006 at Mount St. Helens to estimate the size-duration scaling of the earthquakes associated with the 2004-2008 eruption. We find that the size-duration scaling resembles that of similarly sized tectonic earthquakes observed in other shallow fault zones. We cross-correlate waveforms recorded on 11 broadband stations located less than 2 km from the crater and classify roughly 500 events into 9 families. We observe a size-duration scaling suggesting that the amount of seismically radiated energy per unit seismic moment (scaled energy) is constant within event families, as well as between 7 of 9 event families. Cases where constant scaled energy values vary between families may result from a lack of resolution in the velocity model.

Much of the seismicity from late 2004-2008 occurred on nascent faulting surfaces at the base of several Dacite rock spines extruded over the course of the eruption. The nascent faults exhibited many features commonly observed in shallow faulting zones, such as gouge, striations, and fault-zone cataclasite. The physical fault features and the similarity of the size-duration scaling with that of tectonic earthquakes suggests that the mechanical failure processes of the Mount St. Helens events are consistent with that of typical earthquakes, i.e. stick-slip. However, lower than expected corner frequency values relative to event size suggest that the rupture velocities may be low compared to that of tectonic earthquakes (< 2.5-3 km/s). The low corner frequencies likely result from low shear wave velocities in the volcanic edifice (assuming that the rupture velocity is 0.9*shear-wave velocity), rather than low static stress drop values.