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Temporal changes in attenuation associated with the 2004 M6.0 Parkfield earthquake

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Elevated seismic attenuation is often observed at active fault zones due to the high degree of fracturing and fluid content. However, it is not well constrained how attenuation evolves at the time of an earthquake. Seismicity in the Parkfield area of the San Andreas Fault is well known to be highly clustered in nature. This study uses similar earthquake clusters to investigate temporal changes in attenuation at the time of the 2004 M6.0 Parkfield earthquake. Spectral ratios are calculated between repeating events within earthquake clusters. Data used are from the High Resolution Seismic Network (HRSN), a network of seismometers deployed in boreholes of depths 63 – 572 m. The current instruments in this network have been running continuously since March 2001 with a sampling rate of 250sps. Events used are of magnitude -0.7 to 1.3 and vary in depth from 3-11 km. Within each cluster the range of variation in magnitude is typically 0.2 -0.5 and event locations are typically within 10-20 m, of each other.

Time windows of 0.85 s around each P-wave arrival are extracted and the multitaper method is used when calculating the frequency spectra. The event with the highest signal to noise ratio in each cluster is used as a reference event and spectral ratios of each other event in the cluster to this reference event are computed.

Results show an increase in $\frac{1}{Q}$ of the order of 1 x 10^{-3} (approximately 10 % change in Q_p) after the 2004 M6.0 earthquake. This signal decays over approximately 2 years. The postseismic decay is fit by a logarithmic function. The effects of using different lengths of timewindow and different frequency ranges in the spectral ratio calculation are investigated. Additionally, the effect of potential source variations on the results is also investigated. It is shown that these effects are only accounting for at most a small portion (20 %) of the observed signal.

The greatest changes in attenuation are recorded to the northeast of the fault trace. Our analysis suggests that significant changes in seismic attenuation and hence fracture dilatancy during coseismic rupture are limited to depths of less than about 5 km. The observed temporal signals are interpreted in terms of increased postseismic attenuation due to fracturing and fluid content and subsequent healing.