SEISMIC RECONSTRUCTION OF THE 2012 PALISADES ROCK FALL USING THE ANALYTICAL SOLUTION TO LAMB’S PROBLEM

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Abstract

A rock fall involves a combination of rock detachment, acceleration, impact and settling motion, each of which involves forces that load and unload the Earth, and generates seismic waves. Analysis of the generated seismic signals provide valuable information on the event dynamics in the absence of direct observations.

We investigate a large rock fall that occurred along the west side of the Hudson River Palisades (NY, US), on May 13, 2012 at 00:28 UTC, using seismic signals recorded at a distance of about 2 km. The short distance between the rock fall and the station gives us the opportunity to study the rock-fall-generated seismic signals within the near field. We first characterize the recorded signals to make a quantitative assessment of the association with the rock fall process. We then attempt to model the signals deterministically using a simple model of a rock fall.

Four stages are identified in the seismograms. The first two stages are characterized by two strong pulses, that we associate with the rock detachment from the Palisades cliffs and impact on the riverside bank, respectively. From the observed time difference between the two pulses, we infer that the rock fall detachment that struck the riverside ground first did not start from the top of the cliff, but from a lower height. The last two stages are interpreted as the sliding of the debris along the riverside slope and the gravitational adjustment that the piled material experienced once the propagation ended.

Using the analytic solution to Lamb’s problem (Lamb, 1904), we simulate the seismic wave propagation between the event and seismic station taking into account the elastic properties of the Palisades region. The dynamics and the source history of the Palisades rock fall are reconstructed by analyzing the characteristics of the seismic signal. The seismically-determined force history allows us to model the three-component seismograms and spectra and to obtain estimates of the mass (\(\sim 10^4\) tons) and volume (\(\sim 4 \times 10^3\) m\(^3\)) of the rock fall, which are consistent with estimates based on geological considerations.

Figure 0.1. a) Time-frequency representation of vertical component seismogram recorded on May 13, 2012 at the PAL seismic station. b) Cartoon illustrating the main stages of the Palisades rock fall. c) Synthetic vertical component seismogram (blue) and data (red) filtered between 1 and 3 Hz (Gualtieri & Ekström, in preparation).