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Analysis of seismic signals related to natural and blasting rockfalls (Mount Néron, France)

Pierre Bottelin (1), Denis Jongmans (1), Agnès Helmstetter (1), Laurent Baillet (1), Didier Hantz (1), Dominique Daudon (2), Pascal Villard (2), Frédéric Donzé (2), Vincent Richefeu (2), Lionel Lorier (3), Héloïse Cadet (3), and Alexandre Mathy (3)

(1) ISTerre, Université Grenoble 1, CNRS, F-38041 Grenoble Cedex 9, France, (2) 3SR, CNRS, Grenoble INP, Université Grenoble 1, F-38041 Grenoble Cedex 9, France, (3) Société Alpine de Géotechnique (SAGE), 2 rue de la Condamine, 38610 Gières, France

The eastern limestone cliff of Mount Néron (5 km NW of Grenoble, French Alps) was the theatre of two medium-size rockfalls between summer and winter 2011. On 14 August 2011, a ∼2,000 m3 rock compartment detached from the cliff, fell 100 m down and propagated along the slope. Although most of the fallen rocks deposited in the upper part of the slope, about 15 meter-size blocks were stopped by a ditch and an earthen barrier after a runout of 800 m. An unstable overhanging 2,600 m3 compartment remained attached to the cliff and was blasted away on 13 December 2011. During this artificially triggered event, 8 blocks reached the same barrier, with volumes ranging from 0.8 to 12 m3. These two events, which occurred at the same location, provide a unique opportunity to understand and to compare the seismic phases generated during natural and artificially triggered rockfalls.

The natural event was recorded by a semi-permanent seismic array including short-period vertical sensors and located about 2.5 km from the site. Two additional 3C sensors were temporary deployed at the slope toe to record the provoked blasting event, which was also shot by a digital camera installed on the other side of the valley. Both the natural and blasting events have duration of ∼100 s and the signal maximum amplitudes recorded at large distances are comparable, with computed local magnitude of 1.14 and 1.11, respectively. Most of the energy lies in the 1-30 Hz frequency band. Seismograms of both events exhibit an irregular envelope, with energetic seismic pulses generated at least 50 seconds after the fall. For the provoked event, the comparison with the video allowed associating the main seismic phases with the initial explosion, the impact on the ground after free-fall, the mass propagation down the slope and some block impacts on trees, ditch and earthen barrier. The maximum block velocity at the toe of the slope was estimated at 30 m/s from the video.

The two main energetic phases identified in the signal are the ground impact following the free fall and the impact of one large block (∼9 m3) into the earthen barrier, which exhibit similar amplitudes and low-frequency contents (below 10 Hz).

For the provoked rockfall, polarization analysis was conducted on the 3C seismograms windowed for the two main phases and band-pass filtered in the [2-6 Hz] range. The signal generated by the impact on the earthen barrier exhibits a predominant strong linear horizontal ground motion, oriented perpendicular to the barrier. In contrast, the particle motion resulting from the impact on the ground just after the explosion shows a complex pattern with no specific polarization. A finite-element numerical simulation is carried out to understand the seismic energy released and the wave field generated by these impacts.