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Analysis of the seismic signals generated by controlled single-block rockfalls on soft clay shales sediments: the Rioux Bourdoux slope experiment (French Alps).

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Understanding the dynamics of rockfalls is critical to mitigate the associated hazards but is made very difficult by the nature of these natural disasters that makes them hard to observe directly. Recent advances in seismology allow to determine the dynamics of the largest landslides on Earth from the very low-frequency seismic waves they generate. However, the vast majority of rockfalls that occur worldwide are too small to generate such low-frequency seismic waves and thus these methods cannot be used to reconstruct their dynamics. However, if seismic sensors are close enough, these events will generate high-frequency seismic signals. Unfortunately we cannot yet use these high-frequency seismic records to infer parameters synthetizing the rockfall dynamics as the source of these waves is not well understood.

One of the first steps towards understanding the physical processes involved in the generation of high-frequency seismic waves by rockfalls is to study the link between the dynamics of a single block propagating along a well-known path and the features of the seismic signal generated. We conducted controlled releases of single blocks of limestones in a gully of clay-shales (e.g. black marls) in the Rioux Bourdoux torrent (French Alps). 28 blocks, with masses ranging from 76 kg to 472 kg, were released. A monitoring network combining high-velocity cameras, a broadband seismometer and an array of 4 high-frequency seismometers was deployed near the release area and along the travel path. The high-velocity cameras allow to reconstruct the 3D trajectories of the blocks, to estimate their velocities and the position of the different impacts with the slope surface. These data are compared to the seismic signals recorded. As the distance between the block and the seismic sensors at the time of each impact is known, we can determine the associated seismic signal amplitude corrected from propagation and attenuation effects. We can further compare the velocity, the energy and the momentum of the block at each impact to the true amplitude and the energy of the corresponding part of the seismic signal. Finding potential correlations and scaling laws between the dynamics of the source and the high-frequency seismic signal features constitutes an important breakthrough to understand more complex slope movements that involve multiple blocks or granular flows. This approach may lead to future developments of methods able to determine the dynamics of a large variety of slope movements directly from the seismic signals they generate.